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MATHEMATICAL THEORY OF THE GRAPHICAL EVALUATION OF METEOROGRAPH SOUNDINGS BY MEANS OF THE STÜVE (LINDENBERG) ADIABATIC CHART

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INTRODUCTION

The use of airplanes by meteorological services to obtain pressure, temperature, and humidity values in the free air necessitated the adoption of rapid methods for the evaluation of the records, in order that the data might be communicated as promptly as possible to designated centers for use in air-mass analysis and daily forecasting. Previously, when kites, and captive and sounding balloons were the principal means of making such soundings, it was customary in some services to use a more or less laborious arithmetical method, based on the Laplace hypsometric equation, for computing the heights of the successive levels attained by the recording instrument. This was unsatisfactory because of the time consumed in the computations; and several semigraphical or graphical methods of obtaining essentially the same results were devised. One such method is that of V. Bjerknes (**1**), which necessitates the construction of a diagram with virtual temperature[1] plotted against the logarithm of the barometric pressure, and the use of four auxiliary tables in the computation of heights. A more straightforward graphical method is that of Stüve (**2**), which is an adaptation of the older Hertz-Neuhoff (**3, 4**) adiabatic diagram, with at least one feature (graphical humidity correction) apparently adopted from the Bjerknes virtual-temperature diagram. The resulting diagram (fig. 1), commonly known as the adiabatic chart, also embodies several new and valuable features, and facilitates greatly the evaluation of aerological soundings with an accuracy comparable with that of the observational data. It therefore was adopted by the United States Weather Bureau and other services several years ago.

It is our purpose in this paper: (1), to describe the groundwork coordinate system that forms the adiabatic chart; (2), to show how an airplane meteorological sounding, excepting the determination of altitude, is evaluated through its use; (3), to develop the mathematical theory that underlies the graphical computation of altitude by means of the chart; and (4), to indicate the various graphical methods of different degrees of approximation which may be used on the chart for determining the altitudes of the successive levels of a sounding.

I. GROUNDWORK OF THE ADIABATIC CHART

1. *Temperature and pressure.*—The network of vertical and horizontal lines on the chart (fig. 1) represents a rectangular Cartesian coordinate system, with a uniform scale of temperature for the abscissas, and a logarithmic scale of barometric pressure for the ordinates. The vertical lines, separating unit distances on the abscissa scale, are drawn for each whole degree of temperature in degrees centigrade, with values ordinarily ranging from +35° C. on the right to −45° C. on the left. The horizontal lines extending entirely across the chart and cutting the logarithmic ordinate scale are drawn for every 10 millibars[2] of pressure, with values ordinarily ranging from 1,050 mb at the bottom to 400 mb at the top. The indicated ranges of pressure and temperature suffice for airplane ascents made to elevations of 17,000 feet in continental United States.

In the actual construction of the coordinate system of the adiabatic chart, it is customary in the United States to use a space of 4.5 mm to represent an interval of 1° C. It is also customary to construct the horizontal pressure lines by measuring from the line for 1,000 mb as a datum and drawing the remainder of the lines at distances therefrom in accordance with the relationship $75 \log_{10}\left(\frac{1{,}000}{P}\right)$ cm, where P is pressure in mb. The number 75 is here merely an arbitrary modulus. A smaller scale which is convenient for the construction of larger charts used in the evaluation of sounding balloon observations is two-thirds of that just stated, viz, 3.0 mm per 1° C., and 50 for the modulus of the pressure scale.

On this coordinate system, free-air temperatures obtained from an aerological sounding may be plotted against the corresponding barometric pressures.

2. *Potential temperature.*—The family of curves that run in the general direction from the upper left hand corner of the chart to the lower right hand corner are curves of constant (or equal) potential temperature[3] called "adiabats". The potential temperature, θ in ° K., of air containing an average amount of water vapor (disregarding effects of possible condensation of water vapor), for any given temperature and pressure is computed according to the equation $\theta = T\left(\frac{1000}{P}\right)^{0.288}$, where T is in degrees absolute (Kelvin) and P is in mb and the exponent is the value of $\left(\frac{R}{JC_p}\right)$ in which J is the mechanical equivalent of heat, and R and C_p are respectively the gas constant and specific heat at constant pressure for the humid air. The figures associated with

[1] For the definition of this term see the next section of this article (p. 125).

[2] 1 millibar (mb) represents a pressure of 1,000 dynes per square centimeter, or 1 mb $\left\{\begin{matrix}0.75006 \text{ mm} \\ 0.0295299 \text{ inch}\end{matrix}\right\}$ of mercury under standard conditions of temperature and gravity.

[3] The potential temperature of absolutely dry air may be defined as the temperature it would assume if brought adiabatically, i. e., without gain of heat from the environment or loss thereto, from its given initial conditions of temperature and pressure to a final constant reference pressure, usually (and here) chosen to be 1,000 mb.

the adiabats and running nearly diagonally in the direction from the lower left to the upper right hand corners of the chart represent the potential temperatures corresponding to the given adiabats. It is obvious that an adiabat may be constructed by selecting for θ an arbitrary value, and solving for the values of T corresponding to a series of values assumed for P, or alternatively one might solve for the values of P corresponding to a series of values assumed for T.

Since θ is merely a function of T and P, the potential temperature corresponding to any given temperature humidity. Accordingly, free-air relative humidities may be plotted against barometric pressures (ordinates) for corresponding levels of a sounding.

4. *Vapor pressure.*—The partial pressure of aqueous vapor in the atmosphere, or vapor pressure, is computed from the relative humidities and temperatures observed in the sounding according to the following fundamental relation:

$$e = r \cdot e_s(t)$$

where e=vapor pressure; r=relative humidity (expressed as a decimal); $e_s(t)$=partial pressure of saturated aqueous

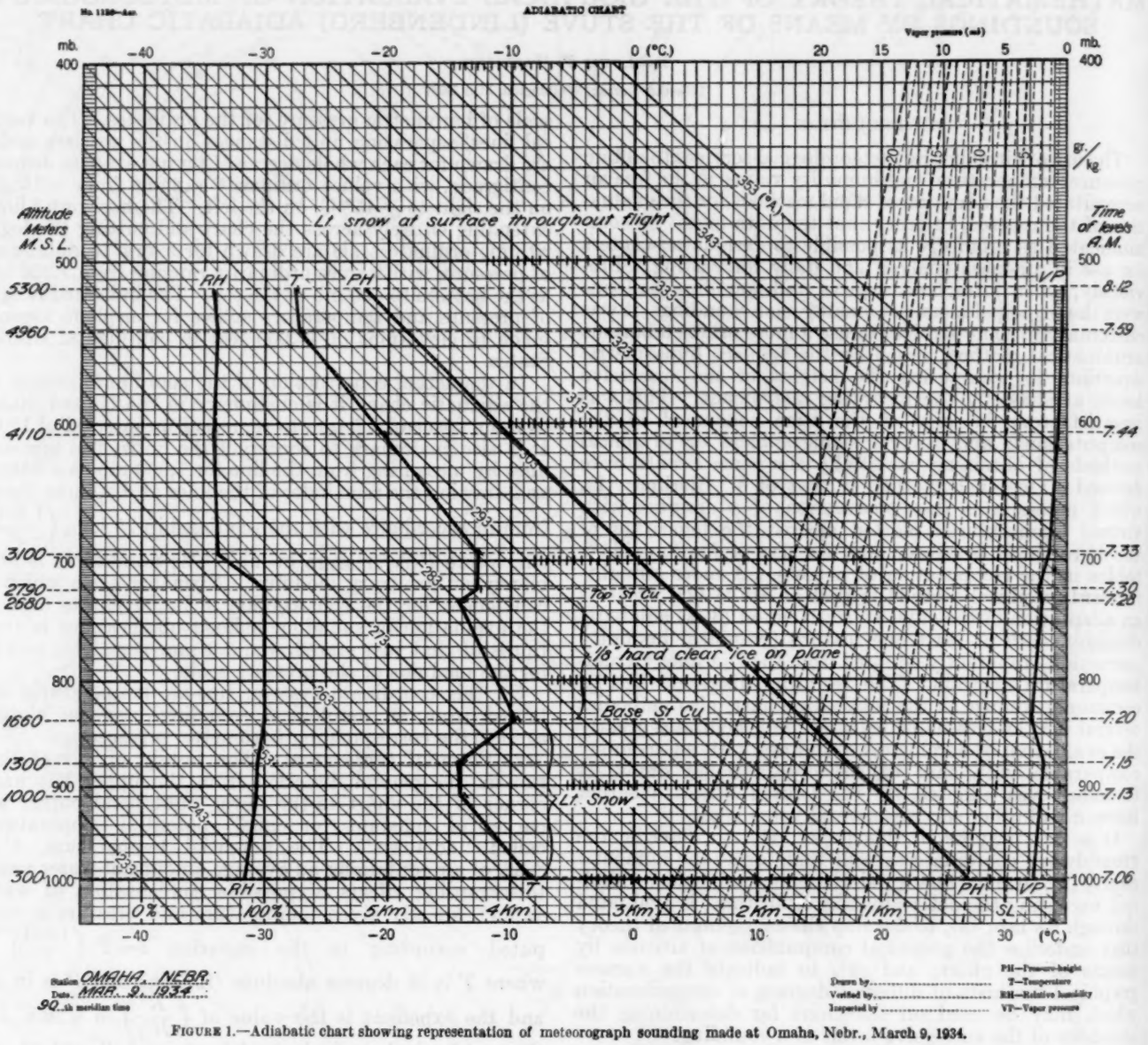

FIGURE 1.—Adiabatic chart showing representation of meteorograph sounding made at Omaha, Nebr., March 9, 1934.

and pressure may be immediately read from the family of curves under consideration.

3. *Relative humidity.*—There is no special scale printed on the chart for plotting relative humidity against barometric pressure; however, it is customary to select some space to the left of the chart, and regard a horizontal interval corresponding to 10° of temperature as representing an interval from 0 to 100 percent of relative vapor (*over water*, where the hair hygrometer is used) at the given temperature of the air, t. Values of $e_s(t)$ are given in the Smithsonian Meteorological Tables and other standard works. The vapor pressure, obtained in the manner just shown, may be plotted (on a horizontal scale) against barometric pressure (on the vertical scale) in the allotted space on the farthest right-hand side of the chart. The scale for this purpose, indicated over the

upper right-hand corner of the chart, is such that a horizontal distance corresponding to 1° of temperature represents a vapor pressure of 1 mb. The zero of this scale coincides with the farthest right-hand margin of the chart, and *increasing values* of vapor pressure are represented *to the left of this*.

5. *Specific humidity.*—The family of curves printed in the form of dashed lines on the right-hand side of the chart represent curves of constant (or equal) specific humidity.[4] The specific humidity of a space that contains the normal proportion of ordinary atmospheric constituents plus water vapor is computed from the equation

$$s=623\,\frac{e}{p-0.377e}\ \text{g/kg}$$

where s=specific humidity in grams of water vapor per kg of moist air; e=vapor pressure; p=barometric pressure. The two arguments necessary for this equation, viz. vapor pressure and barometric pressure, are respectively represented by the horizontal vapor pressure scale on the extreme right side of the chart referred to in the last paragraph, and by the vertical logarithmic scale of barometric pressure forming the ordinates of the chart. The curves corresponding to specific humidities of 5, 10, 15, and 20 g/kg are indicated by figures associated with the appropriate curves. These figures are near the upper portions of the dashed curves (see fig. 1). These curves enable one to ascertain the specific humidities that correspond to given values of vapor pressure and barometric pressure.

6. *Virtual temperature.*—The virtual temperature [5] on the absolute scale, which is used as an auxiliary in computing altitudes by means of the chart, is given by the equation

$$T_v=\frac{T}{1-0.377\frac{e}{p}}$$

where T is the temperature of the air in the absolute scale (degrees Kelvin), $T=(273.2+t)$, t in ° C. The difference between the virtual temperature and the actual temperature of the air is given by

$$(T_v-T)=T\left(\frac{1}{1-0.377\frac{e}{p}}-1\right)$$

If the space under consideration were saturated, the vapor pressure, e, in the above equations would take on a limiting value $e_s(T)$, that is, the saturation vapor pressure which is a function of the air temperature alone. Hence the virtual temperature would take on a corresponding limiting value which we will call the saturation virtual temperature represented by the symbol T_{v}. Then obviously

$$(T_{v}-T)=T\left(\frac{1}{1-0.377\frac{e_s(T)}{P}}-1\right)$$

Thus $(T_{v}-T)$ is a function of T and P alone. The magnitudes of the differences $(T_{v}-T)$ are indicated on the chart by the horizontal distances between the short vertical dashes shown on the horizontal lines corresponding to the multiples of 100 mb. of pressure. The value of T upon which is based each of the differences so indicated is that corresponding to the center of the respective interval.

The last two equations given above may be simplified by performing the indicated divisions on the right-hand sides and neglecting terms containing second or higher powers of $0.377\frac{e}{p}$ or $0.377\,\frac{e_s(T)}{p}$. This is permissible since the latter rarely exceeds 0.02, and thus squares and higher powers are negligible in comparison with the first power. Therefore

$$(T_v-T)=T\left(0.377\frac{e}{p}\right),\ \text{approximately;}$$

and

$$(T_{v}-T)=T\left(0.377\frac{e_s(T)}{p}\right),\ \text{approximately.}$$

Since $e=r\cdot e_s(T)$, (see section 4, where r=relative humidity expressed as a fraction), we have

$$(T_v-T)=r\cdot(T_{v}-T),\ \text{approximately.}$$

Thus

$$T_v=T+(T_v-T)=T+r\cdot(T_{v}-T).$$

Hence if for a given pressure we wish to determine the horizontal position which corresponds to the virtual temperature under the given conditions of actual temperature and relative humidity, we merely find the position that corresponds to the actual temperature and make a displacement *to the right* equal to the fractional part r of the value $(T_{v}-T)$. The latter is indicated by the horizontal distance between the nearest short vertical dashes on the given (horizontal) pressure line. For example, if the relative humidity is 75 percent, the virtual temperature is to the right of the actual temperature by an amount equal to ¾ $(T_{v}-T)$; etc.

For pressures intermediate between the multiples of 100 mb. upon the lines for which the short vertical dashes representing values of $(T_{v}-T)$ are printed, it is obviously necessary to interpolate values of $(T_{v}-T)$ vertically from the printed dashes to obtain values appropriate to the given pressures.

7. *Height.*—A special scale for indicating heights is not printed on the chart; however, as will be proved later, the temperature scale may be made to serve this purpose. A broken line, called the pressure-height curve (indicated by *PH* in fig. 1), is constructed according to a procedure to be described in a later section (IV), and by its aid is obtained the height that corresponds to any pressure observed in the sounding. This is accomplished by first going (vertically) along the pressure scale until one locates on the *PH* curve a point at the pressure for which one desires to find the corresponding height. Then as the theory developed in section III shows, the height (in meters) at which this pressure exists *above the station elevation* is obtained when the constant 102 is multiplied by the *horizontal projection* (*measured in degrees centigrade*) of the *PH* curve in passing from its lower extremity to the given point. To facilitate the computations of height, it is customary to enter near the foot of the chart a height scale, employing a temperature interval of 10° C. to represent a height interval of 1,000 m. However, as stated above, the projections of the *PH* curve must be multiplied by 102 to give heights in meters, so that a

[4] The specific humidity of a given space may be defined as the ratio of the mass of water vapor contained in the space to the total mass of moist air (including water vapor or other gases) in the same space. The unit customarily used to represent specific humidity is: Grams of water vapor per kilogram of moist air, i. e. g/kg, which is a unit 1/1000th as large as that given by the definition.

[5] The virtual temperature of (moist) air at a given barometric pressure is the temperature at which dry air would possess the same density as the given (moist) air when at the same barometric pressure.

10° C. projection really represents 1,020 meters, or 1° C. represents 102 meters. Heights are customarily represented *above sea level* by drawing the *PH* curve so that it is displaced horizontally with respect to the zero of the height scale by an amount (in ° C.) equal to the height (in meters) of the surface station above sea level divided by 102, and then regarding zero height as sea level. In this manner, readings on the height scale, when increased by 2 percent, give true heights above sea level directly.

If the true heights above sea level corresponding to given barometric pressures are known for a number of levels in the free air (as for example when such data are received in daily airplane weather reports), a *true PH* curve may be directly constructed from the data. This curve does not require the 2-percent correction referred to above. (Section IV of this paper may be consulted for further details regarding this type of *PH* curve.)

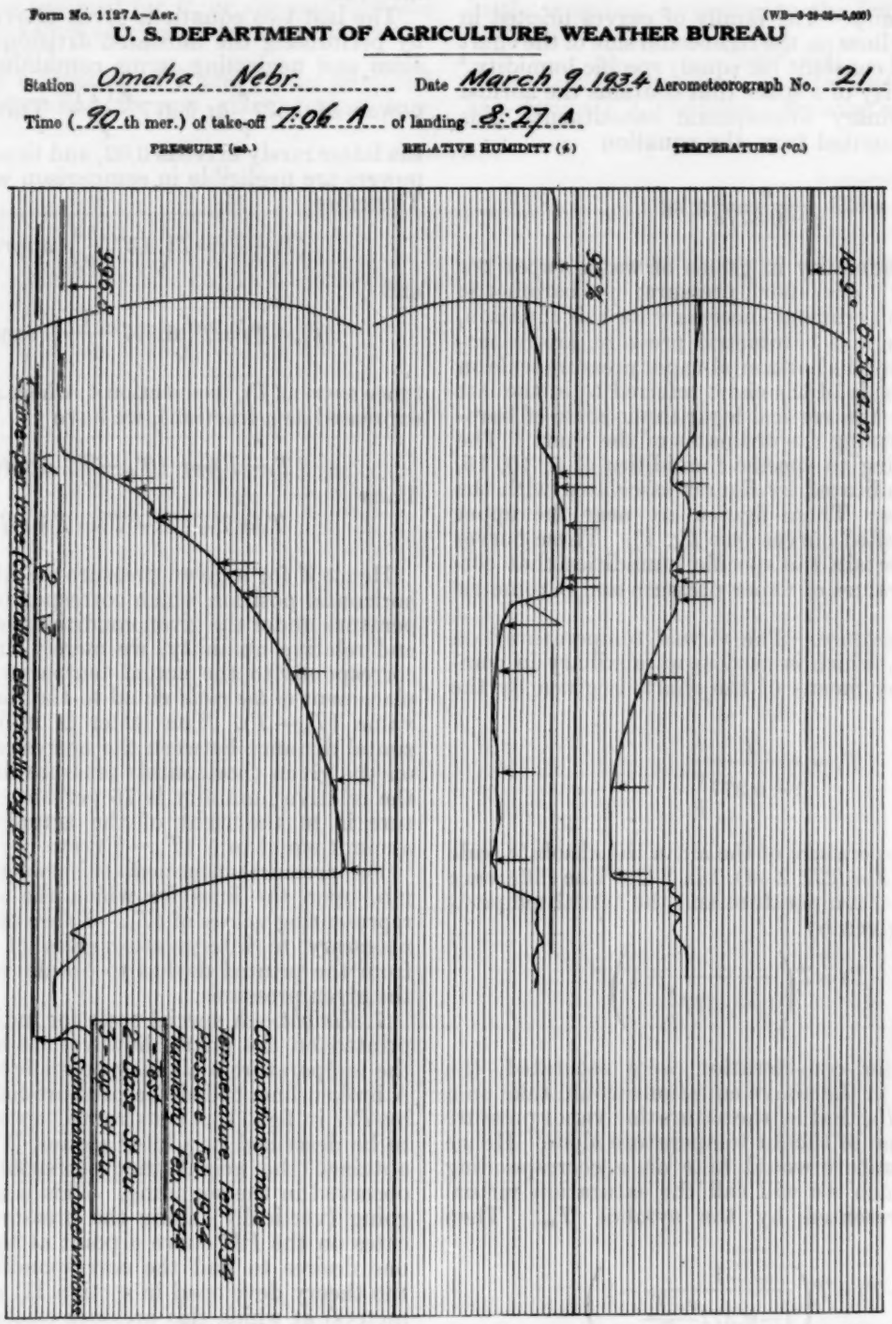

FIGURE 2.—Meteorogram obtained in the sounding made at Omaha, Nebr., March 9, 1934. Arrows indicate points representing "significant levels."

II. PROCEDURE FOLLOWED IN EVALUATING A SOUNDING, EXCEPT FOR DETERMINATION OF ALTITUDES

Figure 2 shows a meteorogram on which are inscribed simultaneous records of the temperature, relative humidity, and barometric pressure in the free air as obtained by means of an aerometeorograph which is illus-

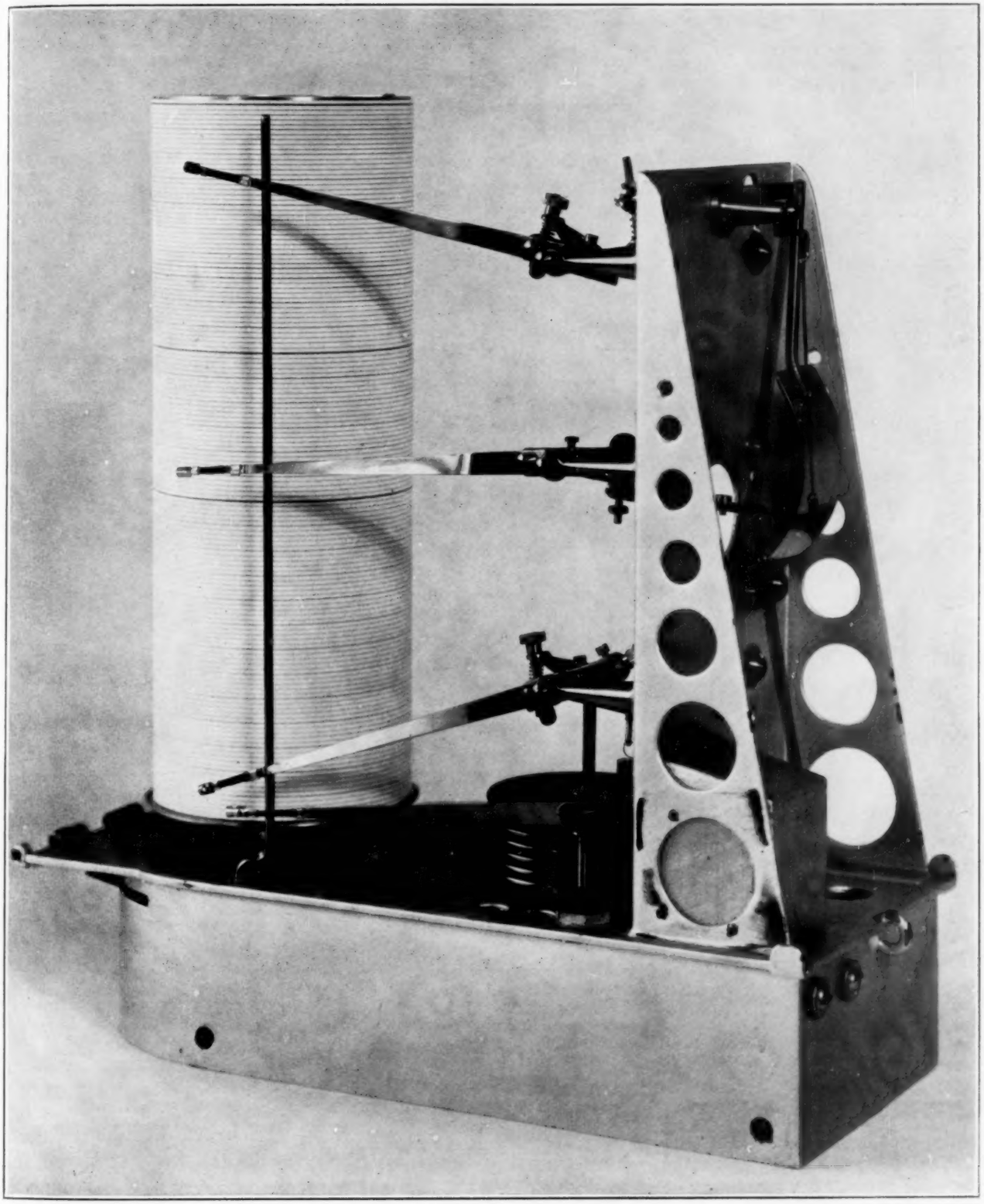

FIGURE 3.—Side view of the Friez type aerometeorograph, with protective cover removed, the instrument carried on United States Weather Bureau observation airplanes to measure and record automatically the temperature, relative humidity and barometric pressure of the free air. On the left is the cylindrical drum which rotates by clockwork and carries a ruled sheet, the meteorogram, on which the three upper pens trace records of the three data in question. Near the lower center is the sylphon element, an evacuated box of thin metal which serves in the capacity of an aneroid barometer. Near the right center, mounted on the upright support, is the curved bimetallic element for measuring the temperature; and beside it, to the left and extending above and below, may be seen a strand of human hairs whose change in length with change in relative humidity permits the measurement of the moisture in the atmosphere. The lowest pen, actuated by a small electro-magnet controlled by a button switch in the pilot's cockpit, is contacted with the meteorogram when the pilot wishes to note the time of any observation during flight.

FIGURE 4.—Side view of Friez type aerometeorograph, with protective cover fastened into place, mounted between the wings of a biplane in a skeleton rectangular frame of metal which is rigidly attached to the sides of the struts. The connections between the corners of the aerometeorograph and the frame are of rubber shock-absorbing cord to reduce vibration of the instrument. The holes on the right of the cover are for ventilating the temperature and humidity measuring elements. The three mica windows near the left permit a view of the pens with the cover closed. The leading edge (to the left) is stream-lined. Dimensions: Length from leading edge to rear =8¾ inches, width =4 inches, height =10 inches, approximately.

trated in figure 3. Figure 4 illustrates the latter instrument mounted on a biplane in position for a sounding.

The following paragraph describes briefly the procedure employed by the Weather Bureau in evaluating the continuous record of free-air conditions made by the instrument in flight after the record is placed at the disposal of the ground observer following the completion of the airplane ascent.

After the completion of a sounding, points are marked off on the meteorogram traces to indicate significant levels, that is, levels where marked changes in the vertical temperature or relative humidity gradients have occurred. Synchronous points on the three traces are determined by taking equal distances along the horizontal time scale measured from the arcs which mark the known time when the pens are finally set to give a continuous record (called second pens-down). The vertical displacements of these synchronous points are measured from the respective base lines of the three traces. (The base lines are horizontal portions of the traces made just prior to the sounding while the aerometeorograph is subjected to known constant conditions of pressure, temperature, and relative humidity in a well-ventilated highly humid box.) The displacements of the given base lines from the base lines employed during the calibration of the instrument are determined by referring the known base-line conditions of p, t, and r to the calibration tables (or curves) for the given instrument and finding the corresponding ordinate displacements. These respective base-line displacements from the calibration positions are added to the appropriate displacements of the synchronous points from the respective base lines for the given meteorogram, and the total ordinate displacements thus obtained when referred to the calibration tables (or curves) give the corresponding values of free-air pressure, temperature, and relative humidity.

[All pressure readings of the instrument are corrected for the effect of temperature upon the pressure recording element in accordance with the well-known equation (5)

$$\delta p = -\Delta t(A + \alpha p)$$

where δp=error in the recorded pressure; Δt=(temperature of instrument at the time error is to be determined) *minus* (temperature of the instrument at the time of the pressure calibration), algebraically; p=pressure indicated by the instrument at the time the error (δp) is to be determined; A and α are constants. $\alpha = -0.00013$, very closely, for the type of instrument pictured in figure 3.

In this type of instrument, when the pressure element is properly calibrated, the value of A for a given instrument should lie between 0.05 and 0.10, preferably at about 0.078. It is not desirable to use a pressure element which has a value of A greater than 0.30.]

The columns headed "Observed values" in table 1 exhibit the free-air barometric pressures, temperatures, and relative humidities obtained from the meteorogram illustrated in figure 2, in the manner outlined in the above paragraph.

The vapor pressures corresponding to the observed values of temperature and relative humidity are next computed by means of the equation

$$e = r.e_s(t)$$

which has already been discussed (I:4). The results of these computations are also shown in table 1.

TABLE 1.—*Evaluation of ascent of Aerometeorograph no. 24, Mar. 9, 1934, 90th meridian time, Omaha, Nebr.*

Significant levels	Observed values				Computed values	Graphically obtained values from chart			
	Time (a. m.)	Barometric pressure	Temperature	Relative humidity	Vapor pressure	Altitude above sea level	Potential temperature	Specific humidity	Virtual temperature −273
		Mb	*°C.*	*Percent*	*Mb*	*Meters*	*°K.*	*Gr./Kg.*	*°C.*
Surface	7:06	998.3	−8.5	84	2.71	300	264.6	1.7	−8.2
1	7:13	910.2	−14.1	94	1.94	1,000	266.0	1.3	−13.9
2	7:15	877.3	−14.3	94	1.91	1,301	268.6	1.4	−14.1
3	7:20	835.2	−9.7	100	2.94	1,657	277.3	2.2	−9.4
4	7:28	732.4	−14.2	100	2.04	2,683	283.1	1.7	−13.9
5	7:30	722.3	−12.8	100	2.29	2,790	285.8	2.0	−12.5
6	7:33	692.6	−12.8	61	1.40	3,096	289.2	1.3	−12.6
7	7:44	606.5	−20.4	58	.70	4,111	291.7	.7	−20.3
8	7:59	540.8	−27.3	60	.39	4,957	293.3	.4	−27.2
9	8:12	515.3	−27.7	57	.36	5,304	296.9	.4	−27.6

PILOT'S NOTES.—Maximum altitude of 17,400 feet reached at 8:12 a. m. Entered base of St Cu clouds at 5,000 feet at 7:20 a. m. (contact no. 2 on meteorogram). Peak of St Cu clouds at 8,800 feet at 7:28 a. m. (contact no. 3 on meteorogram). These were 10/10 overcast. There were 3/10 St clouds at time of take-off but was unable to get contact on base or peak of these. They were estimated to be at 1,500 and 3,000 feet, respectively. Hard, clear ice of about ½ inch thickness was accumulated. Altitudes in feet above surface by altimeter.

ADDITIONAL NOTE.—¼ inch hard, clear ice formed on all exposed parts of plane. Times when plane entered and left clouds in which ice formed: Entered, 7:20 a. m.; left, 7:28 a. m. Times of beginning and ending of precipitation encountered during flight: Snow, 7:06 a. m. (take-off) to 7:20 a. m. Snowing from surface to base of St Cu clouds. Light snow observed at surface throughout flight by weather observer at the airport.

The steps necessary in plotting the results of the sounding on the adiabatic chart are as follows (see fig. 1):

(1) *Isobaric lines.*—First, sets of points are located on the vertical logarithmic pressure scales, one on each side of the chart, to correspond with the respective barometric pressures for the several significant levels. The sets of points on each side of the chart are connected by straight horizontal lines (called isobaric lines).

(2) *Temperature-pressure curve.*—On each of these horizontal (isobaric) lines there is indicated by a dot the temperature prevailing at the corresponding level. These points are connected by straight lines. The letter T is placed at the top and bottom of the broken line thus obtained to identify it as the temperature-pressure curve.

(3) *Humidity-pressure curve.*—A convenient 10° interval to the left of the chart is selected for the humidity scale; then, below the isobaric line that represents the surface barometric pressure there are written the limiting values 0 percent and 100 percent, respectively, at the left and right extremities of this interval. On this horizontal scale an interval of 1° C. thus represents 10 percent of relative humidity. As in the case of temperature, there is indicated by a point on the isobaric line for each significant level the corresponding relative humidity,

and all the points thus plotted are connected by straight lines. The top and bottom of the resulting broken line is labeled with the letters *R H* for identification purposes.

(4) *Vapor pressure-pressure curve.*—Using the horizontal vapor-pressure scale indicated near the upper right-hand corner of the chart, the vapor pressures for the several levels are indicated by placing a point on each of the respective isobaric lines. Straight lines are drawn connecting the points thus obtained, and the broken line so formed is labeled with the letters *V P* at top and bottom.

(5) *Virtual temperatures.*—On each of the isobaric lines drawn, there is indicated by a point the virtual temperature for the level in question. This is accomplished graphically by applying the proper virtual-temperature correction $(T_v - T)$, which is always positive, to the temperature for the same level. To obtain $(T_v - T)$, one goes vertically on the chart from the temperature at the given pressure level to the nearest horizontal lines, above and below, representing pressures which are multiples of 100 mb. Then the values $(T_v - T)$ there indicated by the distances between the short vertical dashes are subdivided graphically to obtain the proportion thereof equal to the relative humidity at the given level. This gives values $(T_v - T)$ for the standard 100 mb isobaric lines, and a slight interpolation is then necessary to reduce to the correction applicable at the isobaric line for the given level. This correction is indicated by a dot (fig. 1) placed at the proper distance to the right of the point representing the temperature for the significant level under consideration. The temperatures corresponding to the positions of these dots consequently represent the virtual temperatures for the levels. The column in table 1 headed "Virtual temperature−273" indicates the values obtained from the results of the sounding illustrated in figure 1.

(6) *Potential temperature.*—The potential temperature for any level, if desired, may be found from the adiabatic chart by noting the value assigned to the adiabat passing through the intersection of the temperature-pressure curve (*T*) with the isobaric line for the level in question. The data in the column of table 1 headed "Potential temperature" shows the values thus found from figure 1.

(7) *Specific humidity.*—The specific humidity for any level, if desired, may be found from the adiabatic chart by noting the value assigned to the curve of constant specific humidity which passes through the intersection of the vapor pressure-pressure curve, *V P*, with the isobaric line for the given level. The column of table 1 headed "Specific humidity, g/kg" indicates the values thus obtained from figure 1.

III. MATHEMATICAL THEORY UNDERLYING THE GRAPHICAL DETERMINATION OF HEIGHTS OF LEVELS IN THE FREE AIR BY MEANS OF THE ADIABATIC CHART

Symbols employed

ρ = density of moist air (grams/cm³).
P = total barometric pressure of moist air (dynes/cm²)*.
e = vapor pressure, i. e. partial pressure of aqueous vapor of moist air (dynes/cm²)*.
T = absolute temperature of moist air (°K.).
T' = virtual temperature of moist air (°K.).
ρ_0 = density of pure dry air under standard conditions of pressure and temperature (grams/cm³).
P_0 = standard pressure (dynes/cm²).
T_0 = standard temperature (°K.).
R = gas constant for 1 gram of pure dry air, $\frac{\text{dyne.cm.}}{\text{gram.°K.}}$
g = acceleration due to gravity at level of moist air (cm./sec.²).
h = height of moist air (cm).
J = mechanical equivalent of heat, ergs/cal.
C_p = specific heat of dry air at constant pressure, cal./gram. °K.

*Pressure units used are dynes/cm² *up to* equation (5), but mb. beginning with equation (5) and continuing.

From the hydrostatic equation, we have, in the free air where the density of moist air is ρ and the gravity acceleration g,

$$dP = -\rho g \cdot dh, \tag{1}$$

in which dP denotes vertical change in barometric pressure and dh change in height.

From the characteristic equation for perfect gases, and from the known ratio between the density of water vapor and that of pure dry air, viz. 0.623 under average conditions, we may express the density of moist air in terms of measurable quantities. Thus

$$\rho = \frac{1}{R}\frac{P}{T}\left(1 - 0.377\frac{e}{P}\right), \text{ where} \tag{2}$$

$$\frac{1}{R} = \rho_0 \frac{T_0}{P_0} \tag{3}$$

from which $R = 2.8686 \times 10^6 \frac{\text{dynes} \cdot \text{cm.}}{\text{grams} \cdot ^\circ \text{K.}}$, where we take the standard values

ρ_0 = density of pure dry air under standard conditions P_0 and T_0, viz. 0.001293 gm./cm.³.

P_0 = 1 atmosphere (=760 mm. of mercury)= 1013250 dynes/cm².

T_0 = freezing point of water = 273.18° K. (6)

Substituting (2) in (1), we obtain

$$\frac{dP}{P} = -\frac{g}{R}\cdot\frac{1}{T}\left(1 - 0.377\frac{e}{P}\right)dh, \tag{4}$$

which is the differential form of the hypsometric equation.

We now proceed to show how the terms in equation 4 may be evaluated by means of the adiabatic chart, and the equation thus solved graphically.

Consider an adiabatic chart formed of a rectangular coordinate system with absolute temperatures, T, as abscissas and $\log_e\left(\frac{1000\ mb.}{P_{mb.}}\right)$ as ordinates (where *P from hereon* is understood to be measured in millibars,[6] i. e., 1,000 dynes/cm², instead of dynes/cm²), upon which coordinate system there is constructed the family of curves of constant potential temperature given by the equation

$$\theta = T\left(\frac{1000}{P}\right)^{\frac{R}{JC_p}}, \tag{5}$$

where J = mechanical equivalent of heat; C_p = specific heat of dry air at constant pressure; R = gas constant for 1 gram of pure dry air.

[6] This is permissible since *P* hereafter occurs only in the form of ratios $\frac{dP}{P}$ or $\frac{e}{P}$, so that if the same units, viz, mb., are used in both numerators and denominators, the values of the ratios remain unchanged whether expressed in dynes/cm² or mb.

The exponent of $\left(\frac{1000}{P}\right)$ is later denoted by k.

(See page 131.)

Taking natural logarithms[7] of both members of this equation, we get

$$\log \theta = \log T + \left(\frac{R}{JC_p}\right) \log \left(\frac{1000}{P}\right), \tag{6}$$

whence

$$\theta = \epsilon^{\log T + \left(\frac{R}{JC_p}\right) \log \left(\frac{1000}{P}\right)}, \tag{7}$$

where ϵ = base of Napierian logarithms.

From (7) it is evident that θ is a scalar point function of the coordinates of the adiabatic chart, T and $\log \left(\frac{1000}{P}\right)$, that is, with each point on the chart specified by a value T and a value $\log \left(\frac{1000}{P}\right)$, there is associated a value of the scalar quantity θ that depends only upon the coordinates of the point. It is therefore permissible to find the rate of change of θ with distance along any direction in the field of the scalar point function θ, viz, the adiabatic chart.

Let s represent distance measured on the adiabatic chart; then taking the directional derivative of θ in the direction of the tangent to any one member of the family of curves θ = constant (adiabats), defined by either of the last three equations, we get from (7), after simplification, since $\theta \neq 0$,

$$\left(\frac{d\theta}{ds}\right)_\theta = 0 = \frac{1}{T}\left(\frac{dT}{ds}\right)_\theta + \left(\frac{R}{JC_p}\right)\left(\frac{d \log \left(\frac{1000}{P}\right)}{ds}\right)_\theta \tag{8}$$

where the notation $\left(\frac{d}{ds}\right)_\theta$ represents differentiation with respect to s in such a direction as to keep θ constant. We note that by taking the directional derivative along the tangent to an adiabat, we are choosing a direction in which θ remains constant, hence the left member of equation (8) becomes zero as indicated.

From (8) we get

$$\frac{1}{T} = -\left(\frac{R}{JC_p}\right) \frac{\left(\frac{d \log \left(\frac{1000}{P}\right)}{ds}\right)_\theta}{\left(\frac{dT}{ds}\right)_\theta} \tag{9}$$

Equation (9) obviously reduces to

$$\frac{1}{T} = -\left(\frac{R}{JC_p}\right)\left(\frac{d \log \left(\frac{1000}{P}\right)}{dT}\right)_\theta \tag{10}$$

where the expression

$$\left(\frac{d \log \left(\frac{1000}{P}\right)}{dT}\right)_\theta$$

just introduced represents the slope of an adiabat in the coordinate system T, $\log \left(\frac{1000}{P}\right)$. Hence (10) states that the reciprocal of the absolute temperature at any point on the adiabatic chart is proportional to the slope of the tangent to the adiabat through that point. A deduction we may draw from (10) is that the slopes of the adiabats at all points along a given isotherm (vertical line on the adiabatic chart) are identical.

Introducing the following simplifying notation, let

$$y \equiv \log \left(\frac{1000}{P}\right), \text{ and} \tag{11}$$

$$x \equiv T; \text{ then equation (10) obviously may be rewritten} \tag{12}$$

$$\frac{1}{T} = -\left(\frac{R}{JC_p}\right)\left(\frac{dy}{dx}\right)_\theta, \text{ where} \tag{13}$$

$\left(\frac{dy}{dx}\right)$ represents the slope of the adiabat on the chart at the coordinates T, $\log \left(\frac{1000}{P}\right)$, i. e., (x, y).

We have thus arrived at a graphical means of expressing the reciprocal of T, which is necessary for the graphical solution of equation (4). There remains the factor $\left(1 - 0.377 \frac{e}{P}\right)$ to take into account. This may be done as follows: From the considerations in the paragraph immediately following equation (10), we note that the slope of an adiabat at a point on the chart depends on the value of the absolute temperature corresponding to that point, but not on the value of $\log \left(\frac{1000}{P}\right)$. Hence for each temperature, T, there is a corresponding slope of the adiabats which is independent of the pressure. Now, consider a point on the adiabatic chart with coordinates T', $\log \left(\frac{1000}{P}\right)$, where, in general, $T' \neq T$. From (13) we get

$$\frac{1}{T'} = -\left(\frac{R}{JC_p}\right)\left(\frac{dy}{dx}\right)'_\theta \tag{14}$$

where the prime associated with the symbol on the right denotes that the pertinent temperature is T' instead of T. From (13) and (14), we get

$$\left(\frac{dy}{dx}\right)'_\theta = \left(\frac{dy}{dx}\right)_\theta \cdot \frac{T}{T'} \tag{15}$$

Let T' have the particular value

$$T' \equiv \frac{T}{\left(1 - 0.377 \frac{e}{P}\right)}, \text{ which is the expression for virtual temperature; then (15) becomes} \tag{16}$$

$$\left(\frac{dy}{dx}\right)'_\theta = \left(\frac{dy}{dx}\right)_\theta \left(1 - 0.377 \frac{e}{P}\right). \tag{17}$$

Now multiplying both members of (13) by the factor $\left(1 - 0.377 \frac{e}{P}\right)$, and substituting (17) in the equation thus obtained, we get

$$\frac{\left(1 - 0.377 \frac{e}{P}\right)}{T} = -\left(\frac{R}{JC_p}\right)\left(\frac{dy}{dx}\right)'_\theta \tag{18}$$

We note that

$$\frac{dP}{P} = d \log P = -d \log \left(\frac{1000}{P}\right) = -dy; \tag{19}$$

[7] Logarithms hereafter designated by "log" represent Napierian logarithms. Logarithms to the base 10 are designated by "$\log_{10}$".

hence on substituting equations (18) and (19) in (4) and simplifying, we obtain the result

$$dh=-\left(\frac{JC_p}{g}\right)\frac{dy}{\left(\frac{dy}{dx}\right)'_\theta} \tag{20}$$

From geometrical considerations, we see that $\left(\frac{dy}{dx}\right)'_\theta$ is the trigonometric tangent of the angle between the adiabat and the isobar (horizontal line) at the point where the coordinates on the adiabatic chart are T', $\log\left(\frac{1000}{P}\right)$; and dy is the vertical distance between two neighboring isobars at the same coordinates. Therefore, the ratio of the latter to the former represents the horizontal projection of that portion of the geometric tangent to the adiabat which is bounded by the two neighboring isobars. That is,

$$dh=-\left(\frac{JC_v}{g}\right)(dx)'_\theta=-\left(\frac{JC_p}{g}\right)(dT)'_\theta \tag{21}$$

where $(dx)'_\theta\equiv(dT)'_\theta$ is the projection, on the axis of abscissas (T axis), of the line-segment tangent to the adiabat at T', $\log\left(\frac{1000}{P}\right)$ and delimited by the isobars

$$\left[\log\left(\frac{1000}{P}\right)-\tfrac{1}{2}d\log\left(\frac{1000}{P}\right)\right]$$

and

$$\left[\log\left(\frac{1000}{P}\right)+\tfrac{1}{2}d\log\left(\frac{1000}{P}\right)\right]$$

Therefore, with the neglect of the small vertical variation in gravity, equation 21 tells us that on the adiabatic chart, *horizontal projections* of small segments of adiabats give a relative (graphical) measure of the differences in height that correspond to given differences in pressure when the virtual temperatures for the intervals of pressure in question are known. Then integrating equation (20) between the limits of height (h_2, h_1) and the corresponding limits of pressure (P_2, P_1), we obtain

$$\int_{h_1}^{h_2}dh=-\left(\frac{JC_p}{g}\right)\int_{P_1}^{P_2}\frac{dy}{\left(\frac{dy}{dx}\right)'_\theta} \tag{22}$$

If the virtual temperature, T', is constant throughout a given finite interval of pressure, then the slope of the adiabat corresponding to this value of T' is constant, that is $\left(\frac{dy}{dx}\right)'_\theta$ =constant; and the integration in equation (22) may be performed since $dy\equiv d\log\left(\frac{1000}{P}\right)$ is integrable. Hence in the special case where T'=constant, we obtain from equation (22) the result

$$(h_2-h_1)=\left(\frac{JC_p}{g}\right)\frac{(y_1-y_2)}{\left(\frac{dy}{dx}\right)'_\theta} \tag{23}$$

where

$$y_1=\log\left(\frac{1000}{P_1}\right)\text{ and }y_2=\log\left(\frac{1000}{P_2}\right)$$

If T' varies in value throughout a given finite interval of pressure, the segments of the adiabats corresponding to the various values of T' must vary in slope; and in general we cannot rigorously perform the integration indicated in equation (22). However, through *small* finite intervals of pressure in the free atmosphere where T' is variable, we may as an approximation adopt a constant value of the slope $\left(\frac{dy}{dx}\right)'_\theta$ which corresponds to the mean value of T' for the interval. That is, we may assume that the integration will be sufficiently exact if we employ a single value of slope that represents the *mean* slope of the segments of the adiabats corresponding to the variable values of T' throughout the interval of pressure. Where the value of T' varies linearly with $\log\left(\frac{1000}{P}\right)$, as is customarily assumed to be the case in aerological work for each successive layer of air (usually) marked off by discontinuities in vertical temperature gradient at top and bottom, the mean value of T' is obviously to be found at the center of the virtual temperature-pressure curve in the interval of $\log\left(\frac{1000}{P}\right)$ for any given layer. Therefore the *mean* slope of the segments of the adiabats that correspond to the variable values of T' in the interval is to be found by determining the center point of the virtual temperature-pressure curve for the interval and taking the slope of the *adiabat passing through, and at, this center point.* Hence if $\left(\frac{dy}{dx}\right)'^{\text{(mean)}}_\theta\equiv m_1$ denotes the slope of the adiabat at the temperature which corresponds to the *mean* virtual temperature (i. e., center) of the interval of $\log\left(\frac{1000}{P}\right)$ in question, we obtain from (22) the result

$$(h_2-h_1)=\left(\frac{JC_p}{g}\right)\frac{(y_1-y_2)}{m_1} \tag{24}$$

which is more general than equation (23).

The variables y_1 and y_2 obviously represent ordinates of isobars on the adiabatic chart, and m_1 represents a slope. Suppose we construct a straight line segment that has slope m_1 and terminates in the isobars y_1 and y_2; then since the equation $(y_1-y_2)=m_1(x_1-x_2)$, where x_1 and x_2 are abscissas corresponding to the ordinates y_1 and y_2 respectively, is the rectangular equation of a straight line, we recognize the expression $(y_1-y_2)/m_1$ on the right of equation (24) as the value (x_1-x_2) of the projection, on the axis of abscissas, of the straight line segment from the point (x_1, y_1) to the point (x_2, y_2). The abscissas x_1, x_2 are temperatures on the chart hence if $T_1\equiv x_1$ and $T_2\equiv x_2$, equation (24) becomes

$$(h_2-h_1)=\left(\frac{JC_p}{g}\right)\cdot(T_1-T_2). \tag{25}$$

Therefore, if we construct a straight line segment on the adiabatic chart, of slope $m_1\equiv\left(\frac{dy}{dx}\right)'^{\text{(mean)}}_\theta$ as defined above, and terminate the segment in the isobars $y_1\equiv\log\left(\frac{1000}{P_1}\right)$ and $y_2\equiv\log\left(\frac{1000}{P_1}\right)$ for the given layer, then the horizontal projection of the line segment expressed in ° K. (or ° C.) gives a value which, when multiplied by the constant factor $\left(\frac{JC_p}{g}\right)$ is the difference in height between the top and bottom of the layer. Since both m_1 and (y_1, y_2) may be constructed graphically on the adiabatic chart, we are thus provided with a graphical means of computing thick-

nesses of layers of air in the free atmosphere, provided the necessary observational data are at hand.

If it is required to compute the elevation of the upper limit of a layer superimposed upon several others, then equation (24) provides the means; for if $h_1, h_2, h_3, \ldots\ldots h_n$ are the elevations of the respective boundary surfaces separating the successive layers (h_1 being the bottom of the lowermost layer, and h_n the top of the uppermost layer), $y_1, y_2, y_3, \ldots\ldots y_n$ are the corresponding ordinates on the adiabatic chart as derived from the observed barometric pressures, and $m_1, m_2, m_3, \ldots\ldots m_{(n-1)}$ are the appropriate slopes for the respective layers (subscripts indicating the identification numbers of the lower boundaries), then for each layer we obtain an equation similar to equation (24) and by addition of these $(n-1)$ equations we obtain the result

$$(26)\quad (h_n-h_1)=\left(\frac{JC_p}{g}\right)\cdot\left[\frac{(y_1-y_2)}{m_1}+\frac{(y_2-y_3)}{m_2}+\ \ldots\ +\frac{(y_{n-1}-y_n)}{m_{n-1}}\right]$$

If h_1 is the elevation of the surface of the ground above sea level, then the elevation h_n above sea level is obviously

$$(27)\quad h_n=\left(\frac{JC_p}{g}\right)\left[\frac{g}{JC_p}\cdot h_1+\frac{(y_1-y_2)}{m_1}+\frac{(y_2-y_3)}{m_2}+\ \ldots\ +\frac{(y_{n-1}-y_n)}{m_{n-1}}\right]$$

Equation (27) tells us that we may graphically determine the elevation above sea level of any point in the free air, in terms of the total horizontal projection on the adiabatic chart of the appropriate straight line segments for the successive layers of air, provided we add an allowance for the elevation of the ground equal to $\left(\frac{g}{JC_p}\cdot h_1\right)$; (see the curve designated *PH* in fig. 1).

It is now necessary to evaluate the term $\left(\frac{JC_p}{g}\right)$. When the value of C_p refers to perfectly dry air we recognize this as the expression for the reciprocal of the dry adiabatic lapse rate (see, for example, Humphreys' Physics of the Air, second edition, 1929, p. 28). To compute this term on the basis of the latest accepted values of the several constants involved, we shall adopt the following values:

$J=4.1852 \times 10^7$ ergs per 15° calorie (given by Birge (**6**)); $C_p=0.2405$ cal.$_{15°}$/gram . ° K. at one atmosphere pressure and 0° C. for dry air free of CO_2 (given by Holborn, Scheel, and Henning (**7**)); this should be essentially the same as C_p for atmospheric dry air containing 3 parts of CO_2 per 10,000 parts of air, since the value of C_p for CO_2 is 0.197 at 0° C.

The value of C_p given by Moody (**8**) (viz, 0.2412 cal.$_{20°}$/g.°K. at one atmosphere pressure and 20° C.) when reduced to the standard conditions employed above, becomes 0.24057, in essential agreement with that adopted herein.

The values of gravity acceleration (g) herein adopted are based on the United States Coast and Geodetic Survery formula (**9**) for the variation of g with latitude at sea level, and Helmert's formula (**10**) for the variation of g with height above sea level. Since most airplane weather observation ascents attain an elevation of about 5,000 meters, we shall employ values of g pertinent to the mean height of 2,500 m. Thus we obtain:

g (at $\varphi=30°$, $h=2500$ m.)$=978.556$ cm./sec^2.
g (at $\varphi=40°$, $h=2500$ m.)$=979.400$ " "
g (at $\varphi=50°$, $h=2500$ m.)$=980.299$ " "
g (standard gravity) $=980.665$ " "

where φ=latitude, and h=height above sea level.

Let k denote the exponent of $\left(\frac{1000}{P}\right)$ in eq. (5) [also the constant coefficient in eq. (18)], then (compare equations 4, 18, 19, and 20) from the above values of the adopted constants we find

$$\frac{1}{k}\left(\frac{R}{g}\right)=\frac{1}{\left(\frac{R}{JC_p}\right)}\cdot\left(\frac{R}{g}\right)=\left(\frac{JC_p}{g}\right)$$

$=10286$ cm./°K. for $\varphi=30°$, $h=2500$ m.
$=10277$ " " $\varphi=40°$, "
$=10268$ " " $\varphi=50°$, "
$=10264$ " " standard gravity.

Converting these to round numbers expressed in meters per ° K., we finally obtain 103 meters per ° K. for the value of $\left(\frac{JC_p}{g}\right)$. Hence applying this to equations (23)–(27), we arrive at the conclusion that *if the adiabats are constructed* on the adiabatic chart *in accordance with the constants here adopted*, a horizontal projection of 1° C. by a straight line segment of proper slope corresponds to a difference of elevation of 103 meters.

If the adiabats are not constructed on the adiabatic chart in accordance with the values of the constants adopted above, then the factor 103 just discussed is not applicable in general. Thus if we evaluate the exponent $k\left[=\left(\frac{R}{JC_p}\right)\right]$ in equation (5) on the basis of the adopted constants, we obtain $k=0.2850$ instead of 0.288 as usually employed; the latter value is commonly assumed to be the one appropriate to average values of humidity. Assuming that $k=0.288$, then for $\phi=40°$, $h=2500$ m.,

$$\frac{1}{k}\left(\frac{R}{g}\right)=\frac{1}{0.288}\cdot\frac{2.8686\times10^6}{979.400}=10170\text{cm./°}K$$

and for standard gravity 10157 cm./°K.

Therefore, *when the adiabats are constructed on the basis of 0.288 as the exponent, which is the case in figure 1, we must employ a factor of 102 meters per °K.* in determining heights graphically by means of the adiabatic chart.

NOTE.—One may inquire why, if the actual adiabatic chart (fig. 1) has its ordinate system constructed on the basis of the relation $y_{10}\equiv 75\log_{10}\left(\frac{1000}{P}\right)$, is it permissible to consider the theoretical chart which we have discussed in this section with an ordinate system constructed on the basis of the relation $y_e\equiv\log_e\left(\frac{1000}{P}\right)$. Since $\log_{10}\left(\frac{1000}{P}\right)=M\log_e\left(\frac{1000}{P}\right)$, where M is the modulus of common logarithms, 0.43429+, $y_{10}=(75\,M)\log_e\left(\frac{1000}{P}\right)=(75\,M)\,y_e$. Then $dy_{10}=(75\,M)\,dy_e$, and if $x\equiv T$ as before, $\left(\frac{dy_{10}}{dx}\right)_\theta'=(75\,M)\left(\frac{dy_e}{dx}\right)_\theta'$. By division, we have $\frac{dy_{10}}{\left(\frac{dy_{10}}{dx}\right)_\theta'}=\frac{dy_e}{\left(\frac{dy_e}{dx}\right)_\theta'}$; but equation (20) is equivalent to

$$dh=-\left(\frac{JC_p}{g}\right)\frac{dy_e}{\left(\frac{dy_e}{dx}\right)_\theta'},$$

hence by virtue of the equality just previously found we may rewrite this equation in the form

$$dh=-\left(\frac{JC_p}{g}\right)\frac{dy_{10}}{\left(\frac{dy_{10}}{dx}\right)_\theta}.$$

Therefore, all the discussion regarding the graphical computation of height is as valid in the case of the actual adiabatic chart as in the case of the theoretical adiabatic chart.

IV. VARIOUS METHODS FOR THE CONSTRUCTION OF THE PRESSURE-HEIGHT (PH) CURVE ON THE ADIABATIC CHART, AND GRAPHICAL COMPUTATION OF HEIGHTS OF FREE-AIR LEVELS

From equation (27) it is obvious that we may graphically determine the elevation above sea level corresponding to any pressure in the free air by adding the horizontal projections (on the axis of abscissas= temperature) of several straight line segments of appropriate slope, one for each successive stratum of air, assuming an allowance is made for the elevation of the ground above sea level. We recall that the straight line segments in question must terminate in the isobars (ordinates) for the upper and lower limits of each respective stratum, and that they must each have an appropriate slope corresponding to the slope of the tangent to the adiabat at the center of the "virtual temperature-pressure" curve for the stratum (which is assumed to be linear). Under these circumstances, a horizontal projection of any segment equal to 1° C. corresponds to a difference in elevation of 102 meters.

To facilitate the addition of the horizontal projections of the straight-line segments required by equation (27), instead of constructing each segment so that its center coincides with the center of the virtual temperature-pressure curve for its particular stratum, which requires the addition of separate horizontal projections, we may displace each one horizontally, maintaining the same slope, until they join at their extremities and form a continuous (broken-line) curve. The continuous curve thus formed is called the pressure-height (*PH*) curve, shown in figure 1.

To facilitate the determination of the magnitude of the total horizontal projection of any portion of the *PH* curve from its origin (lower terminus) to any point on the curve, it is most convenient to place the origin so that the projections in degrees Centigrade may be read off at a glance. Since each degree Centigrade of projection corresponds to 102 meters elevation, it is convenient to regard the temperature scale as a sort of height scale, whereby the projection in degrees increased by 2 percent gives the elevation in hundreds of meters. Thus a 10° horizontal projection corresponds to 1,020 meters, or 1 k[illegible]plus 20 meters.

The following instructions briefly indicate a procedure for the construction of the *PH* curve on the adiabatic chart, and the determination of the elevations that correspond to the pressures at the various levels attained in an aerological ascent (see fig. 1):

(1) Immediately below the isobar that corresponds to the barometric pressure at the surface, write in the height-scale values: 0 km (or S. L., representing "sea level"), 1 km, 2 km, 3 km, 4 km, 5 km, 6 km, etc., increasing values extending to the left, one value beneath successive vertical lines for consecutive printed 10° intervals of temperature. The origin (i. e., S. L. position) of this scale is placed somewhere to the right of the chart at any suitable arbitrary point located on a vertical line representing a 10° multiple of temperature. (This scale is in error by 2 percent as mentioned above, but serves to facilitate the exact computation of elevations.)

(2) Place a dot on the surface pressure isobar with reference to the height scale (constructed as just indicated) at the apparent height equal to $(h_1/1.02)$ (see first term in brackets in equation (27)), where h_1 is the height of the station above sea level, more particularly the height at which the isobar in question represents the existing barometric pressure. (This should be the same height as that at which the station temperature reading was made—usually the height of the instrument shelter). For example, if both the surface barometric pressure and temperature refer to the height 300 meters above sea level, the dot should be placed at the position on the horizontal height scale corresponding to the height 300/1.02 or 294 meters. This dot is the origin of the *PH* curve.

(3) To construct the segment of the *PH* curve for the first stratum of air above the station, first refer to the temperature-pressure, *T*, curve for this stratum and mark by dots the virtual temperatures corresponding to the top and bottom, respectively, of the stratum. Imagine a line through these two dots, the "virtual temperature-pressure" curve, and mark a dot at the *center* of this imaginary line. (This dot represents the *mean* virtual-temperature for the stratum.) Find the adiabat passing through this (central) dot, or if an adiabat does not happen to pass through the dot, place some identifying mark such as a small cross on a point located vertically above the dot and lying on an adiabat. Place a draftsman's triangle at the dot or cross in question and orient it until one edge thereof is tangent to the adiabat at the point marked by the dot or cross. (This gives the slope of the straight line segment corresponding to the mean virtual temperature for the stratum.) Place a straight-edge, such as a ruler, against one of the edges of the triangle other than that which is tangent to the adiabat, and slide the triangle by parallel displacement until the tangential edge passes through the origin of the *PH* curve, which is the dot marked in the manner indicated in paragraph (2) above. Draw a straight line segment along the tangential edge, starting it in the dot just referred to and ending it in the isobar for the top of the stratum. This is the first segment of the *PH* curve.

NOTE.—Instead of employing a draftsman's triangle and a straightedge as indicated above, a set of parallel rules may be used to advantage, especially in making the parallel displacement of slope.

(4) The segments of the *PH* curve for the other successive strata of air may be obtained in a manner similar to that just described for the first stratum; in each case the *initial point for any segment is the terminal point of the segment for the preceding lower stratum.* Thus a succession of segments may be constructed to form a continuous curve, marked by the letters *PH* in figure 1.

(5) To determine the elevations corresponding to the several isobars on the chart which represent the significant levels attained in the sounding, from each point where the *PH* curve intersects an isobar project an imaginary vertical line down on the height scale and read the value there indicated. *Increase each reading by 2 percent of itself,* thus finally obtaining the actual elevations in meters above sea level. The results found in this manner for the aerological sounding illustrated in figure 1 are entered in table 1 in the column headed "Altitude

above sea level, meters." These results are also entered in figure 1 in the left-hand margin just above each respective isobar.

NOTE.—Once the *PH* curve is constructed, the pressure, temperature, or other data corresponding to any particular elevation may be obtained. Thus:

(6) To determine the pressure corresponding to any given elevation, the *PH* curve must be employed in a manner the inverse of that just described. First divide the given elevation by the factor 1.02, then imagine a point on the horizontal height scale at this *diminished* elevation (i. e., $h/1.02$) and move vertically on the chart from this point until the *PH* curve is intersected. The required pressure may be determined by reading the pressure scale on the side of the chart at the isobar passing through the point of intersection in question.

(7) The values of the temperature, virtual-temperature, relative humidity, vapor pressure, potential temperature, or specific humidity corresponding to any given elevation may be determined by finding the isobar corresponding to that elevation as outlined in paragraph (6) and then noting the values of the desired elements at the intersections of the appropriate curves with the isobar in question.

It may be seen from equation (27) that if the *slope* of each segment of the *PH* curve constructed in the manner indicated in the preceding paragraphs *be decreased in the proportion (1/1.02)*, then the horizontal projections of the resulting straight line segments will fulfill the condition that 1° C. of projection corresponds to 100 meters difference in elevation instead of 102 meters. Hence, if we can modify the slopes in this proportion, the horizontal height scale referred to in paragraph (1) will give *actual* heights above sea level directly without a correction of 2 percent being necessary. This assumes, of course, that the origin of the new *PH* curve is placed at the position on the scale corresponding to height h_1 instead of $(h_1/1.02)$ as before. The slopes of the segments may easily be *decreased* in the required proportion if the horizontal projection of each segment of the original *PH* curve which we have described be *increased* in the proportion (1.02/1). This is most easily accomplished by (1) constructing a *PH* curve in the manner described in paragraphs (1)–(4) or preferably by placing a dot on each isobar where the original *PH* curve would intersect the isobar; (2) reading the horizontal projections of these dots on the height scale and increasing these readings by 2 percent; (3) placing new dots on the respective isobars at positions vertically above the height scale corresponding to the readings increased by 2 percent just referred to; and (4) constructing a new *PH* curve formed of straight line segments connecting the new dots. This new *PH* curve has the advantage that elevations corresponding to any pressure attained in the sounding may be read directly on the height scale. Conversely, pressures corresponding to any elevation may be determined directly by noting the pressures on the side of the chart at the level of the isobar that passes through the point in the *PH* curve vertically above the point on the height scale where the given elevation is marked.

Instead of making the slope of each segment of the *PH* curve parallel to the *tangent* to the appropriate adiabat at the point where it passes through the center of the virtual-temperature-pressure curve (or vertically above or below that central point), one might employ the approximation of making the slope of each segment respectively parallel to the *chord* of the portion of the appropriate adiabat bounded by the isobars for the given stratum. This may easily be accomplished with the aid of a draftsman's compass. Briefly, the instructions for this procedure are as follows:

(*a*) Beginning with the stratum between the ground and the first significant level, set the point of a compass on the intersection of the proper printed adiabat and the surface pressure isobar. With the compass thus centered, mark a point on the surface pressure isobar at the place on the horizontal height scale (see paragraphs nos. 1 and 2 above) that corresponds to the station elevation divided by the factor 1.02 (i. e., $h_1/1.02$). With this same setting of the compass, place one compass point on the intersection of the proper adiabat with the isobar for the first level. With the compass thus set, mark a point on this isobar with the other compass point extended toward the left of the chart. The point thus finally obtained on the isobar for the first level and the point designated by $h_1/1.02$ on the horizontal height scale marked on the surface pressure isobar, represent the upper and lower termini respectively of the first segment of the original *PH* curve discussed in paragraph number (3) above.

(*b*) Next, adjust the compass to the distance between the point last obtained and the intersection of the proper printed adiabat for the second stratum of air with the isobar for the first level. With this setting, place one point of the compass on the intersection of the adiabat just referred to with the isobar for the second significant level, and mark a point on this isobar with the other compass point extended toward the left of the chart. This latter point represents the upper terminus of the segment of the original *PH* curve for the second stratum, while the point last obtained in the preceding paragraph represents the lower terminus of this segment.

In a similar manner the points for all the segments of the *PH* curve may be obtained. If desired, these points may be displaced to the left in the increased proportion of 2 percent on the horizontal height scale, thus giving a new set of points through which a *PH* curve may be drawn that gives actual elevations above sea level directly without correction.

The objection to the method just outlined, wherein chords of adiabats instead of tangents are used to obtain the segments of the *PH* curve, is that it is tantamount to assuming that the vertical virtual-temperature gradient of each stratum is always equal to the dry adiabatic gradient of approximately −1 ° C. per 100 meters, whereas actually the vertical virtual-temperature gradients may have a wide range from positive values (inversions) to superadiabatic values (algebraically less than −1 ° C./100 m). This may be seen from the following considerations. A section of an adiabat subtended by a chord must have identically the same horizontal projection as the chord. Therefore, since the difference in elevation between two levels is determined merely by the horizontal projection of the portion of the *PH* curve lying between the respective isobars for the two levels, the chord may be replaced by the portion of the adiabat which it subtends when constructing the portion of the *PH* curve lying between the isobars in question. That is, the portion of the *PH* curve for the given stratum may be made curvilinear instead of linear and yet give the same difference in elevation between the top and bottom of the stratum so long as the same horizontal projection obtains in both cases. From the interpretation of the symbol

$$\left(\frac{d\log\left(\frac{1000}{P}\right)}{dT}\right)'_{\theta},$$

(see discussion following equations 10, 14, and 20, sec. III), which controls the construction of segments of the *PH* curve, and from equation (18), we note that a *given slope* of a tangent to an adiabat at a point must correspond to an *equivalent virtual temperature* represented by an isotherm (*vertical line*) passing through the point of tangency. Also, the virtual temperature corresponding to a given point on the *PH* curve must be represented as being at the same pressure that is applicable at the point in question, i. e., the isobar (*horizontal line*) passing through the point must intersect the virtual temperature-pressure curve for the stratum at a point having the appropriate virtual-temperature value. Thus, if we chose a point *A* on the portion of the adiabat which forms the *PH* curve for the stratum, there must in general, be a point *B* on the virtual temperature-pressure curve for the same stratum which lies both on a vertical line passing through *A* and on a horizontal line passing through *A* also. The only way in which both these things may occur is for *B* to coincide with *A*. If we apply this argument to every point on the curvilinear section of the *PH* curve, we conclude that the virtual temperature-pressure curve must coincide with the portion of the adiabat in question. Therefore, by constructing the *PH* curve out of chords of adiabats, we do the equivalent of assuming that the vertical virtual-temperature gradient is equal to the dry adiabatic gradient. The only justification for the procedure under consideration would appear to be the practical one that tangents to adiabats cannot be obtained with great accuracy in ordinary work, and that the errors involved through the use of chords are of the same order of magnitude as those involved through the determination of tangents.

We have shown in the preceding paragraph that the *PH* curve for a stratum wherein the vertical virtual-temperature gradient is equal to the dry adiabatic gradient should rigorously be curved and not straight,

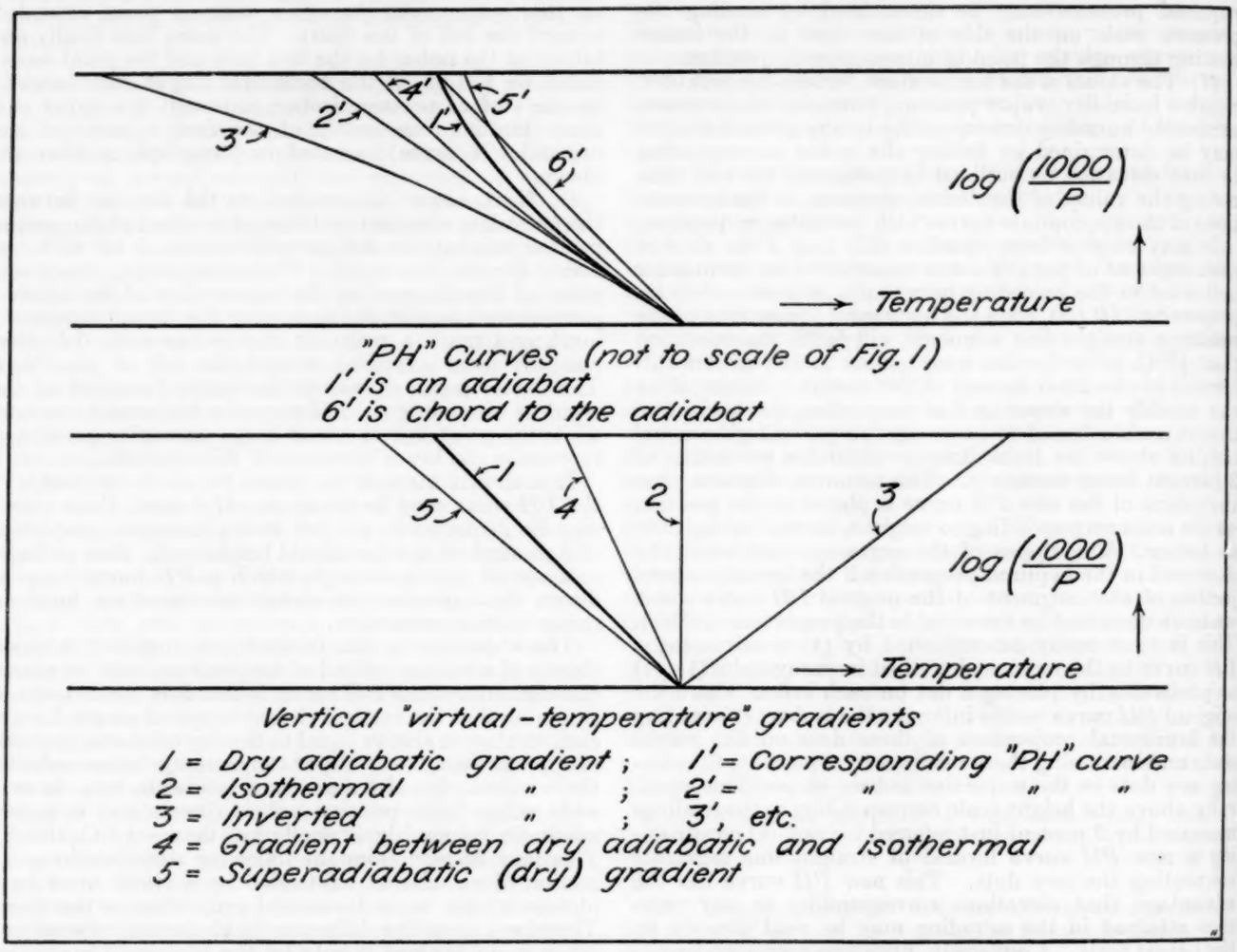

FIGURE 5.—Examples of appropriate *PH* curves (greatly exaggerated) for various vertical virtual-temperature gradients.

and should have a curvature and form identical with that of the portion of the adiabat along which the virtual temperature-pressure curve for the stratum lies. However, when the vertical virtual-temperature gradient is zero, that is when the virtual temperature remains constant with decreasing pressure throughout a stratum, equation (18) indicates that the slope of the adiabats at every point along the virtual temperature-pressure curve must remain constant. Therefore, when conditions in a stratum are isothermal with respect to virtual temperature, the *PH* curve for the stratum should rigorously be a straight line. On the other hand, when the vertical virtual-temperature gradient is such that the virtual

temperature increases with decreasing pressure, or in other words when an inversion of virtual temperature prevails in a stratum, the *PH* curve for the stratum should again be curved. Reference to the adiabatic chart portrayed in figure 1 will show that the adiabats are concave *upwards*, and that tangents to the adiabats tend to approach verticality at lower temperatures, and horizontality at higher temperatures. Therefore it follows that the appropriate *PH* curve for a stratum that has an inversion of virtual temperature should rigorously be concave *downwards*, i. e., opposite in curvature to the *PH* curve for a stratum with a dry adiabatic vertical virtual-temperature gradient.

By virtue of the facts presented in the preceding two paragraphs, it is obvious that a linear *PH* curve rigorously has a sort of median position between the appropriate *PH* curves for dry adiabatic and inverted vertical virtual-temperature gradients. This may be best seen from figure 5, which shows the three types of *PH* curves in question, *with greatly exaggerated curvature* to illustrate their respective differences; the *mean virtual temperature for the stratum* is different for each different vertical virtual-temperature gradient. Since the virtual temperature at the bottom of the given stratum shown in figure 5 is fixed, the slope of the *PH* curve at the corresponding pressure level is the same no matter what the vertical virtual-temperature gradient is in the stratum immediately above. Therefore the three *PH* curves in question all start with the same slope, viz, that corresponding to the slope of the adiabats at the virtual temperature of the bottom of the stratum. This must be the slope of the linear *PH* curve which would obtain for isothermal conditions of virtual temperature. Then as a consequence of the upward concave character of the curve appropriate for dry adiabatic conditions, and of the downward concave character of the curve appropriate for inverted conditions of virtual temperature, the two curves in question must deviate from the straight line, the former to the right and the latter to the left. The differences between the horizontal projections of the respective *PH* curves shown in figure 5 are largely accounted for by the different mean virtual temperatures for the stratum that correspond to the different virtual temperature-pressure curves shown in the lower part of the figure. If the mean virtual temperature were identical for each given virtual temperature-pressure curve, then the horizontal projections would be the same in each case.

The discussion in the last paragraph suggests that a very nearly rigorous *PH* curve may be constructed by employing templates of various curvatures depending upon the mean virtual temperatures and upon the vertical virtual-temperature gradients of the particular strata. For example, one can prepare sets of templates for say three different mean virtual temperatures. Each set may consist of templates for the following vertical virtual-temperature gradients: (1) Dry adiabatic, (2) half-way between dry adiabatic and isothermal, (3) isothermal (use straight edge), (4) moderate inversion, and (5) strong inversion. Possibly (4) and (5) may be replaced by one suitable intermediate template. The templates may be made of some transparent material, such as celluloid, similar in form to that of a triangle with one side having a curvature appropriate to a given mean virtual temperature and a given vertical virtual-temperature gradient. This triangle may conveniently be slid to and fro with one straight edge parallel to the isobars, while the curved edge retains the proper direction relative thereto. The range of vertical virtual-temperature gradients to which the given template pertains may be graphically indicated by two fine dark lines of proper slope inscribed on the transparent material. These refinements are of course not justified in many cases; under such circumstances the methods previously outlined for the construction of the *PH* curve may be employed.

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FLOODS IN THE SACRAMENTO VALLEY DURING APRIL 1935

By E. H. FLETCHER

[Weather Bureau, Sacramento, Calif., May 1935]

On April 6–7 a low-pressure area of marked intensity and wide extent, whose center moved inland from the ocean along the California-Oregon boundary, caused heavy rains generally throughout northern California, culminating in torrential downpours in several localities of the Sacramento basin. This was the primary cause of the flood in question. However, there were two other contributing factors of importance.

First, there was an unusually heavy snow cover in the mountain area at moderate elevations; and the rapid runoff that occurred over the American, Feather-Yuba, and upper Sacramento drainage areas was augmented by melting snow from rains that extended well up into the mountain snow fields. The material source of snow water was in a belt from about 4,000 to 5,000 feet, where the snow was less compact. The winter and early spring

had brought unusually heavy snowfall to the mountain area that is drained by the streams tributary to the Sacramento and lower San Joaquin Rivers. The seasonal snowfall at Norden, elevation 6,871 feet, near the Sierra summit, to the end of March 1935, was 546 inches, which is the greatest fall for a corresponding period since 1907, and the accumulated depth on the ground April 6 was 144 inches, with the snow line extending down to the 4,000-foot level or lower in places.

Second, at the beginning of the storm referred to above, river stages were already rather high in the valley streams.

On Sunday morning, April 7, following the precipitation of a preceding storm, there was a crest at Colusa of 21.9 feet, and the stages at Knights Landing and Sacramento were also fairly high, 28 and 21.6 feet, respectively. At this time the new storm was setting in throughout northern California, and during the next 24 hours rainfall was general, but not exceedingly heavy except over the drainage areas of the American and Bear Rivers and the creeks east and west of Red Bluff. In these areas local rains of cloudburst proportions were experienced late Sunday. At Sacramento, unprecedented excessive precipitation occurred, the total for a 24-hour period being 3.35 inches, of which 1.65 inches fell within 1 hour and 2.62 inches in 2 hours. This established a new maximum rainfall intensity record for Sacramento for periods up to 2 hours. Sewers were inadequate to carry the volume of water, resulting in the flooding of streets and basements in the low sections of the city. Water backed up into the first floor of the State Capitol and other buildings.

Definite information was not available Sunday evening as to the extent of the torrential rains, but with the storm continuing it was evident that a near flood was in the offing. Therefore, a general warning was broadcast and messages dispatched to the river observers at Red Bluff and Hamilton City, including all others on the special warning list, that the Sacramento River would rise rapidly, reaching a stage of 22 feet Monday, April 8, at Red Bluff and 18 or 19 feet at Hamilton City Monday night. Early Monday morning flood warnings were issued for Knights Landing.

Excessive local rains over the Cottonwood and Battle Creeks areas on either side of Red Bluff caused the water to rise in that vicinity with great rapidity Sunday night, cresting Monday morning at Red Bluff with a stage of 23.6 feet, which was exceptionally high in proportion to the volume of water that came from upstream as indicated by the station of Kennett. In past years when a first order station was maintained at Red Bluff the official in charge there usually was able to supply some special information in regard to excessive local run-off from creeks in that vicinity. Oldtime residents on the east side of the valley south of Red Bluff reported that the run-off from local creeks was the greatest they had ever known.

It was just another instance of the erratic behavior of the streams of the Sacramento Valley, where even the output of a single creek with headwaters in the mountain area may cause a serious situation in the main stream, when excessive precipitation is localized.

The intensity of the flood crest that originated largely in the vicinity of Red Bluff was not sustained farther down the stream, due to the lack of proportionate run-off. The crest had flattened to 18.8 feet when Hamilton City was reached late Monday night. Crest stages occurred at Colusa and Knights Landing on Wednesday, April 10, the former at 25.1 feet, or 0.4 foot less than that forecast, and the latter at 30.2 feet, which was 0.3 foot below the stage expected.

The fact that the water slightly exceeded the flood stage for a few hours at Red Bluff without being forecast specifically as a flood was of no special importance, because the warnings that had been disseminated, in effect, covered the situation. This was true because the main interests to be served are in the lowlands farther down the stream where stages were not higher than expected. In reality no damage occurred in the immediate vicinity of Red Bluff.

Likewise, the American and Bear Rivers rose with great rapidity Sunday night, causing the Sacramento River at Sacramento to crest Monday evening at a stage of 28.6 feet, or 0.1 foot above that forecast, and 1 foot below the high-water mark established in March 1928, when the town of North Sacramento, situated across the American River from Sacramento, was completely flooded.

On Monday morning the water from the American River, which flows between the two cities, overspread an irregular area adjacent to the river. The few families living in this low area, outside the recently completed flood control levee that was constructed to protect North Sacramento, were driven from their homes and places of business, and highway traffic was interrupted when the floodgates to the passage through the levee on Del Paso Boulevard were closed Sunday night to keep out the oncoming water. By Thursday morning, April 11, the overflow water from the American River had receded sufficiently for the main highway between the two cities to be opened for traffic.

The levee that was constructed about the city of North Sacramento after the destructive flood of 1928 effectively protected that city during this high water.

The gates of the Sacramento Weir (constructed to protect the city of Sacramento from flood waters) were not opened; but at noon Monday the Courtland telephone operator was requested to distribute warnings to those in the lower Yolo basin area that water to a depth of about 1½ feet was flowing over the entire length of the 48 gates of the Sacramento Weir, and that Fremont Weir, already discharging freely, would intensify the danger in the lower bypass region within the next day or two.

The operation of the Sacramento Weir is under the control of the State Reclamation Board, and the gates may be opened when the situation warrants, which is usually well in advance of the occurrence of the flood stage, provided a critical situation is indicated. Therefore, the forecast of a definite stage in such emergencies is of vital importance, because to open the weir gates would result in wholesale destruction in the bypass area where substandard levees are the only protection to many thousands of acres of highly cultivated land, yet to defer the opening of the weir gates too long, especially if a heavy volume of water is yet to come, may endanger the populous area at Sacramento.

Unofficial reports that had gained wide circulation to the effect that another and more intense flood wave from the up-Sacramento River soon would be due unnecessarily alarmed the already highly frantic populace in and about Sacramento, and occasioned an additional deluge of inquiries to the Weather Bureau, where the single telephone service, from the beginning of the storm, was able to accommodate only a small percentage of the thousands who tried to call. One official of another department stated that he was unable to receive more than a "busy" response from the Weather Bureau telephone number during a 2-hour effort. On Monday morning the United States Commissioner, who has an office adjoining that of the Weather Bureau, kindly lent

us the use of his telephone for a few hours. The additional service permitted the official in charge to answer the many long-distance calls that were awaiting his attention.

Relieving the excess flood waters that accumulated in the section from Knights Landing to the mouth of the Feather, Fremont Weir discharging into Yolo bypass at the rate of about 67,000 second-feet during the peak flow on the 10th–11th, was the principal source of the water that menaced thousands of acres of the low bypass lands, much of which had already been planted to crops. The greatest monetary loss resulted from the breaking of the levee on Prospect Island, which was planted to asparagus and other truck crops. This island and Little Holland Tract, situated near the outlet of Yolo bypass, were completely inundated. No doubt the relief afforded by the breaking of the levee on Prospect Island, causing the water level to drop about 10 inches, was a factor in saving the nearby Liberty Island from a similar fate.

Aside from the lower Yolo basin area, damage to agricultural lands and growing crops was limited, and mostly confined to small areas adjacent to streams in a few localities. Much of the submerged areas in the valleys were pasture and alfalfa lands where little or no damage resulted, stockmen having moved their livestock to higher grounds when warnings were received. With river stages remaining high for about a month, the continuation of seepage damage to lowlands abutting the levees in the lower valley areas caused considerable concern to agricultural interests.

Torrential local rains in a few foothill sections caused considerable damage in the way of washouts to highways and railroads. Heavy damage was reported to have been done to hillside orchards in Placer County by erosion of topsoil. Minor damage to levees occurred locally on the lower reaches of streams. A break occurred in the north levee of the lower Bear River in the vicinity of Wheatland and a hundred or more acres of alfalfa and orchard land were flooded, but the resultant damage was light. Also little loss resulted from the flooding of considerable acreage along the lower Cosumnes River above its confluence with the Mokelumne, in the lower San Joaquin basin.

The fact that practically all the water of the upper Mokelumne River want into storage in Pardee Dam on that stream, prevented what otherwise would have been a rather serious flood situation on the lower Mokelumne. As it was, the Cosumnes alone caused a near flood at the river station of Bensons Ferry on the lower Mokelumne. On the morning of April 8, cautionary warnings were issued for the streams tributary to the lower San Joaquin River. The Feather and Yuba Rivers were only moderately high. Had they been proportionately high as compared with other streams, the Knights Landing area would have suffered a serious flood and much more destruction would have been caused in the lower Yolo Basin.

With a recurrence of heavy local rains in the American and Bear River areas on April 15, these streams, especially the American, carried considerable water, and with the Sacramento already high, 23.3 feet at 8 a. m. of that date, cautionary warnings were issued to the effect that the river at Sacramento would rise to 26 feet during the night and that a portion of the low area between the two cities would again be submerged, and at the same time advised that the flood-control gates on Del Paso Boulevard be closed.

On the following morning the river at Sacramento peaked at a stage of 26.1 feet. Limited areas of the lowlands adjacent to the north side of the American River were covered with water, but as normal activities in that low region had not been resumed little damage resulted. By the morning of April 18 receding waters permitted the gates of the highway to be opened for traffic.

Five lives were lost by drowning: One at Sacramento when a boat of a rescuing party capsized, three in the vicinity of Lincoln, Placer County, east of Auburn, when local creeks suddenly overflowed their banks, and one at Vina, Tehama County, where a rancher was thrown from his horse while rounding up cattle in the flooded area.

The damage to property as a result of this flood was estimated at $526,150; and the value of the property saved by the Weather Bureau's warnings was estimated to be $318,000.

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING APRIL 1935

By IRVING F. HAND, *Assistant in Solar Radiation Investigations*

For a description of instruments employed and their exposures, the reader is referred to the January 1935 REVIEW, page 24.

Table 1 shows that solar radiation intensities averaged close to normal for April at both Washington and Madison, and slightly above normal at Lincoln.

Table 2 shows a deficiency in the amount of solar and sky radiation received on a horizontal surface at all stations except Chicago, New York, Fairbanks, and Twin Falls.

Polarization measurements obtained on 6 days at Washington give a mean of 59 percent with a maximum of 64 percent on the 22d and 26th. At Madison the single observation obtained of 51 percent on the 13th is below both the average and the maximum normal for that month at that station. The Washington values are close to the April normals.

Owing to change of personnel at Twin Falls, total solar and sky radiation data were received too late to include in any of the first three issues of the REVIEW for 1935. The values for the first 13 weeks of 1935, expressed in gram calories, are as follows: 180, 142, 175, 199, 264, 106, 306, 294, 305, 306, 405, 388, and 409 with an excess at the end of April of 651.

TABLE 1.—*Solar radiation intensities during April, 1935*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance									
	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Apr. 2	7.29	------	------	------	------	1.05	------	------	------	------	9.47
Apr. 17	3.99	------	------	0.79	------	------	------	------	------	------	4.75
Apr. 18	4.37	0.55	0.66	.80	1.00	1.33	------	------	------	------	4.57
Apr. 22	6.50	------	------	.76	1.05	1.44	------	------	------	------	5.79
Apr. 23	5.36	.52	.66	.84	1.02	1.38	------	------	------	------	4.75
Apr. 25	6.27	.76	.94	1.06	1.18	1.45	1.12	.95	------	------	3.99
Apr. 26	3.81	.90	.97	1.10	1.29	1.45	------	------	------	------	4.37
Means	------	.68	.81	.89	1.11	1.35	(1.12)	(.95)	------	------	------
Departures	------	−.02	+.03	.00	+.04	−.01	+.02	+.05	------	------	------

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during April, 1935*—Contd.

MADISON, WIS.

Date	Sun's zenith distance: 8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	08.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	x	5.0	4.0	3.0	2.0	[1] 1.0	.0	3.0	4.0	5.0	e
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
Apr. 2	3.99	------	.84	1.02	------	------	------	------	------	------	2.90
Apr. 3	2.26	------	.99	1.19	1.31	------	------	------	------	------	2.49
Apr. 9	4.37	------	.81	------	------	------	------	------	------	------	4.57
Apr. 13	3.81	------	------	1.15	1.33	------	------	------	------	------	4.57
Apr. 16	2.62	------	------	------	------	1.45	.98	------	------	------	3.45
Apr. 20	5.56	------	------	.70	------	------	------	------	------	------	6.50
Apr. 22	4.75	------	------	------	------	1.44	1.08	------	------	------	5.16
Apr. 24	8.18	------	------	------	------	------	1.02	------	------	------	8.81
Apr. 30	4.57	------	------	------	------	1.55	------	------	------	------	3.99
Means	------	------	.88	1.02	(1.32)	1.48	1.03	------	------	------	------
Departures	------	------	−.02	.00	+.13	+.04	−.16	------	------	------	------

LINCOLN, NEBR.

Apr. 3	2.87	------	------	------	------	1.40	1.13	.91	0.76	0.60	2.62
Apr. 15	2.16	.81	.95	1.13	1.32	1.57	1.35	1.14	.92	------	2.16
Apr. 19	3.99	.64	.80	.99	1.20	1.42	1.20	.94	.75	.60	4.95
Apr. 20	5.36	------	------	------	1.14	------	------	------	------	------	4.95
Apr. 29	5.36	------	1.03	1.16	------	------	------	------	------	------	4.37
Means	------	(.72)	.93	1.09	1.22	1.45	1.23	1.00	.81	(.60)	------
Departures	------	+.01	+.12	+.13	+.03	+.01	+.07	+.04	−.01	−.08	------

TABLE 1.—*Solar radiation intensities during April, 1935*—Contd.

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date	Sun's zenith distance: 8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	x	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
Apr. 3	3.2	------	.79	.96	1.16	1.45	1.32	1.14	.98	.85	2.9
Apr. 4	2.3	------	------	------	------	1.42	------	------	------	------	1.8
Apr. 5	2.0	------	------	1.09	1.29	1.52	1.14	------	------	------	1.0
Apr. 7	1.5	------	------	------	------	1.55	1.23	1.07	------	------	1.5
Apr. 15	5.0	------	------	------	1.23	1.53	------	------	------	------	4.2
Apr. 16	------	------	------	1.05	1.27	1.48	------	------	------	------	------
Apr. 18	3.8	------	------	1.18	1.24	1.42	------	------	------	------	3.8
Apr. 20	4.2	------	------	------	1.36	1.53	1.23	------	------	------	4.4
Apr. 21	5.6	------	------	------	1.21	------	------	------	------	------	5.0
Apr. 25	5.2	------	------	------	1.11	------	------	------	------	------	2.3
Apr. 26	3.0	------	------	1.15	1.31	1.50	------	------	------	------	1.4
Apr. 27	4.2	------	------	------	1.04	------	------	------	------	------	2.6
Apr. 28	10.3	------	------	------	------	1.40	.79	------	------	------	6.8
Apr. 29	5.2	------	------	------	1.22	1.47	1.06	------	------	------	7.4
Averages	------	------	.79	1.09	1.22	1.48	1.13	1.10	.98	.85	------

[1] Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	Miami	New Orleans	Riverside	Blue Hill	Mount Washington	Friday Harbor	Ithaca
	Gram-calories per square centimeter														
1935	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Apr. 2	177	400	264	290	366	417	322	316	473	308	398	452	------	445	322
Apr. 9	280	318	381	276	156	510	405	455	498	424	511	192	------	474	226
Apr. 16	448	429	562	408	451	637	461	492	481	348	534	422	------	262	383
Apr. 23	578	377	421	447	527	559	419	623	403	315	345	[1] 371	------	596	534
	Departures from weekly normals														
Apr. 2	−200	+28	−156	−10	+30	−100	−12	−113	+5	−50	−64	------	------	------	------
Apr. 9	−114	−83	−49	−60	−166	−59	+27	−7	+24	+84	+25	------	------	------	------
Apr. 16	+26	+30	+121	+48	+89	+43	+63	+34	+22	−24	+33	------	------	------	------
Apr. 23	+131	−62	−36	+91	+125	−3	+24	+115	−77	−55	−177	------	------	------	------
	Accumulated departures on Apr. 29														
	−1,533	−4,445	−987	+889	+1,568	−931	+1,407	+854	−1,022	−1,099	−2,891	------	------	------	------

[1] Bulb burned out by lightning—record incomplete.

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during April 1935, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated*

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	$\beta_{I_{m-y}}$	$\beta_{I_{y-r}}$	β_{m-sun}	$\frac{I_{m-y}}{1.94}$ (Percentage of solar constant)	$\frac{I_{m-r}-I_m}{1.94}$ (Percentage of solar constant)	w	Air-mass type
Apr. 5, 1935	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
3:19 a. m.	32 29	1.86	1.200	0.827	0.691	0.063	0.116	0.090	68.0	6.1	6.9	P_c
3:00 p. m.	35 35	1.75	1.365	.966	.760	.026	.024	.025	82.2	11.8	8.1	
4:49 p. m.	16 33	3.49	1.061	.775	.652	.036	.071	.054	60.5	5.8	3.6	P_c
Apr. 6												
2:57 a. m.	36 52	1.66	1.270	.898	.713	.049	.080	.064	70.9	5.2	7.4	P_c
2:37 a. m.	40 03	1.55	1.316	.913	.744	.054	.088	.071	74.7	6.8	8.5	
0:16 p. m.	54 00	1.24	1.442	.992	.799	.054	.075	.064	79.7	5.3	10.0	P_c
Apr. 7												
0:33 a. m.	53 42	1.24	1.457	1.007	.810	.041	.067	.054	81.2	5.9	10.2	P_c, T_A aloft
1:05 p. m.	51 39	1.27	1.385	.965	.772	.058	.075	.066	79.1	6.6	10.3	
3:23 p. m.	32 54	1.84	1.255	.905	.731	.058	.077	.068	72.1	7.3	7.2	
3:46 p. m.	28 57	2.06	1.189	.862	.690	.056	.058	.057	71.8	10.4	6.8	P_c
Apr. 15												
3:03 a. m.	38 20	1.61	1.331	.914	.720	.027	.041	.034	81.0	11.9	8.9	
2:44 a. m.	42 18	1.48	1.357	.925	.725	.024	.044	.034	82.1	11.7	9.6	NP_c, T_m aloft
0:40 a. m.	56 14	1.20	1.364	.931	.738	.049	.076	.062	80.7	9.9	13.1	
0:08 a. m.	57 21	1.19	1.442	.968	.769	.035	.065	.050	82.4	7.6	11.1	
Apr. 18												
3:18 a. m.	36 40	1.67	1.250	.907	.701	.077	.075	.076	72.2	7.3	7.9	P_c, NP_c aloft
2:43 a. m.	42 34	1.48	1.335	.917	.743	.042	.072	.057	78.0	8.4	9.1	
Apr. 20												
0:32 a. m.	58 23	1.18	1.300	1.011	.803	.019	.025	.022	86.9	8.8	11.9	NP_c
April 21												
3:31 a. m.	35 32	1.72	1.330	.952	.755	.041	.038	.038	79.4	10.2	7.5	NP_A
Apr 25												
2:58 p. m.	41 46	1.50	1.273	.890	.725	.067	.088	.078	74.4	8.0	9.0	NP_c
Apr. 26												
3:14 a. m.	35 14	1.58	1.416	.968	.786	.025	.069	.046	78.8	4.9	7.7	NP_c
1:44 a. m.	53 24	1.25	1.445	.980	.785	.027	.040	.034	84.3	8.9	11.4	
Apr. 27												
2:26 a. m.	47 59	1.34	1.173	.809	.653	.096	.144	.120	70.6	9.3	10.3	NP_c
Apr. 28												
1:28 p. m.	56 59	1.19	1.257	.839	.669	.065	.125	.095	76.1	10.4	11.7	NP_y
3:30 p. m.	36 52	1.66	.957	.698	.567	.147	.164	.156	61.0	11.0	8.4	P_c
Apr. 29												
3:16 a. m.	39 35	1.57	1.285	.884	.708	.042	.075	.058	76.3	9.2	8.7	NP_c
2:46 a. m.	44 38	1.42	1.344	.918	.729	.039	.064	.052	79.6	9.3	9.6	
0:02 p. m.	62 06	1.13	1.400	.950	.750	.050	.060	.055	82.3	9.1	13.1	
0:35 p. m.	61 06	1.14	1.405	.950	.750	.036	.075	.056	81.9	8.4	11.8	
2:39 p. m.	45 54	1.39	1.273	.889	.702	.061	.067	.064	77.8	11.3	10.2	P_A, T_c aloft

Atmospheric conditions during solar radiation measurements. Blue Hill Observatory of Harvard University

Date and time from apparent noon	Air temperature	Wind (Beaufort scale)	Visibility (scale 0–10)	Sky blueness	Cloudiness and remarks
April 1935	°C.				
3; 2:45 a. m.	3.9	NW 5	8–9	8	Few Acu, 5 Cu, light haze.
3; 0:14 p. m.	4.4	NW 6	8–9	9	3 Cu, Stcu, light haze.
3; 2:45 p. m.	6.1	NW 7	9	9	6 Cu, Stcu, no haze. Gusty. Wind variable.
4; 0:28 p. m.	6.1	W 3	8–9	8	3 Acu, 2 Cu, light haze.
6; 2:54 a. m.	1.7	NNW 5	7–9	9	Few Ci, moderate haze. Wind steady. Varying smoke.
6; 0:09 a. m.	3.9	NxW 5	9	9	Few Ci, light haze. Wind rising gusty.
6; 0:03 p. m.	3.9	NxW 5	9	9	Do.
6; 1:41 p. m.	5.0	NW 5	9	10	4 Ci, light haze.
7; 0:50 a. m.	2.8	N 3	9	12	4 Ci, no haze. Smoke from N. Audibility good.
7; 1:18 p. m.	5.6	NE 3	9	12	1 Ci, light smoke N.
7; 3:23 p. m.	6.1	ESE 1	9	[1] 5	Few Ci.
15; 3:00 a. m.	7.8	WNW 3	8	11	3 Acu, few Stcu, moderate water haze.
15; 0:31 a. m.	12.8	SSW 4	8	10	Few Ci, Dist, 2 Cu, light haze.
18; 3:01 a. m.	3.3	NW 5	7–8	9	Few Cicu. 4 Acu, few Cu, moderate haze.
20; 1:14 a. m.	13.3	NW 5	9	[1] 5	4 Ci, 5 Cu.
20; 0:20 a. m.	13.9	NW 5	9	[1] 5	Do.
26; 3:30 a. m.	10.0	NW 5	8–9	11	Few Ci. Wind gusty. Light haze.
26; 1:09 a. m.	12.2	NW 5–6	9	11	2 Ci, light haze. Gusty.
28; 3:13 a. m.	18.3	WSW 5	7	7	Few Frcu, heavy haze. Gusty, wind rising.
28; 1:25 p. m.	23.6	W 7	8	3	2 Ci, 1 Cu, heavy haze.
29; 3:14 a. m.	12.2	E 4	8–9	10	1 Ci, no haze.
29; 0:17 p. m.	15.6	NE 4	8–9	10	Few Ci, few Frcu, no haze.
29; 2:42 p. m.	18.3	S 5	8–9	11	Few Ci, few Cu, no haze.

[1] Observation by Towle; others by E. M. H.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy, Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1935	h m	°	°	°				
Apr. 1	11 30	(1)	(1)	(1)	-------	-------	-------	Mt. Wilson.
Apr. 2	11 34	(1)	(1)	(1)	-------	-------	-------	U. S. Naval.
Apr. 3	13 29	(1)	(1)	(1)	-------	-------	-------	Do.
Apr. 4	9 40	(1)	(1)	(1)	-------	-------	-------	Mt. Wilson.
Apr. 5	9 15	(1)	(1)	(1)	-------	-------	-------	Do.
Apr. 6	11 15	(1)	(1)	(1)	-------	-------	-------	Do.
Apr. 9	13 35	+5.0	304.2	+25.0	-------	24	-------	Do.
		+27.0	326.2	−21.0	-------	12	36	
Apr. 10	13 15	+18.0	304.2	+25.0	-------	21	-------	Do.
		+40.0	326.2	−21.0	3	-------	24	
Apr. 11	13 21	+36.0	308.9	+24.0	-------	15	15	U. S. Naval.
Apr. 12	13 10	−64.0	195.8	−28.0	-------	8	-------	Mt. Wilson.
		−39.0	220.8	−36.0	-------	23	-------	
		+50.0	309.8	+25.0	-------	12	43	
Apr. 13	12 30	−54.0	193.0	−27.0	10	-------	-------	U. S. Naval.
		−26.5	220.5	−35.0	-------	123	-------	
		+64.0	311.0	+24.0	-------	15	148	
Apr. 14	13 47	−14.0	219.0	−36.0	-------	231	231	Do.
Apr. 15	11 40	−2.0	219.0	−36.0	-------	293	293	Do.
Apr. 16	13 7	+10.0	217.0	−35.0	-------	231	231	Do.
Apr. 17	11 1	+22.0	217.0	−35.0	-------	216	216	Do.
Apr. 18	11 24	+34.0	215.5	−35.0	-------	170	170	Do.
Apr. 19	11 10	+50.0	218.5	−35.0	-------	154	154	Do.

[1] No spots.

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total Area for each day	Observatory
Apr. 20	10 50	+60.5	215.9	−35.0	147		147	Do.
Apr. 21	13 15	−54.0	86.9	−36.0		3		Mt. Wilson.
		+76.0	216.9	−35.0	283		286	
Apr. 22	13 9	(1)	(1)	(1)				U. S. Naval.
Apr. 23	10 56	−59.0	56.7	−21.5	10		10	Do.
Apr. 24	11 19	−45.0	57.3	−20.5	8		8	Do.
Apr. 25	11 30	(1)	(1)	(1)				Do.
Apr. 26	11 0	(1)	(1)	(1)				Do.
Apr. 27	11 17	(1)	(1)	(1)				Do.
Apr. 28	13 38	(1)	(1)	(1)				Do.
Apr. 29	10 14	−71.5	325.3	−25.5		73	73	Harvard.
Apr. 30	11 9	−70.0	313.1	+23.0	69			U. S. Naval.
		−57.5	325.6	−22.5		31	100	

[1] No spots.

NOTE.—Mean daily area for April, 78.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS, APRIL 1935

(Data dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen, Sternwarte, Zurich, Switzerland]

April 1935	Relative numbers	April 1935	Relative numbers	April 1935	Relative numbers
1	0	11	16	21	15
2	0	12	*Ec* 22	22	16
3	0	13	34	23	9
4	7	14	30	24	7
5	0	15	*b* 37	25	8
6	0	16	29?	26	0
7	0	17		27	0
8	*Mc* 11	18	20	28	0
9	*a* 24	19	11	29	*d* 8
10	22	20	16	30	*d* 16

Mean, 29 days=12.3.

a=Passage of an average-sized group through the central meridian.

b=Passage of a large group or spot through the central meridian.

c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.

d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in Charge]

By L. T. SAMUELS

At those stations which have a sufficient period of record to determine approximate normals, free-air temperatures during April averaged below normal, except at Pensacola and in the higher levels at San Diego, Omaha, and Norfolk. (See table 1.) Mean temperatures for April at Seattle and Spokane were higher than those at Boston below 3,000 meters, but above this level the temperatures at Boston averaged higher.

Free-air relative humidities averaged above normal at all stations except Boston, with the largest departures occurring at Norfolk. Mean free-air relative humidities for April were high in the upper levels over Murfreesboro compared to surrounding stations.

The directions of the resultant winds for the month at 1,000 meters contained greater northerly components than normal over the northeastern part of the country, with resultant velocities normal at all stations.

At 3,000 meters, the directions were generally close to normal, except at a few stations in the northeast and on the Pacific coast where northerly components predominated. Velocities were mostly above normal, except over the Great Lakes region and the extreme northwest.

At 5,000 meters, the directions were generally close to normal, except at a few more northern stations where northerly components were predominant, and on the California coast where greater southerly components prevailed. Velocities were close to normal except at San Diego and Salt Lake City, where large positive departures occurred, and at Cheyenne and Chicago, where large negative departures occurred.

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during April 1935*

TEMPERATURE (° C)

Stations	Altitude (meters) m. s. l.: Surface Mean	Surface Departure from normal	500 Mean	500 Departure from normal	1,000 Mean	1,000 Departure from normal	1,500 Mean	1,500 Departure from normal	2,000 Mean	2,000 Departure from normal	2,500 Mean	2,500 Departure from normal	3,000 Mean	3,000 Departure from normal	4,000 Mean	4,000 Departure from normal	5,000 Mean	5,000 Departure from normal	Number of observations
Billings, Mont.[1] (1088 m)	−0.3						1.9		0.1		−2.9		−6.1		−12.7		−19.2		29
Boston, Mass.[2] (6 m)	5.9	−1.1	3.9	−0.4	1.3	−1.1	−1.2	−2.0	−3.3	−2.0	−5.3	−1.8	−7.1	−1.3	−11.3	−0.6	−17.6	−0.7	16
Cheyenne, Wyo.[1] (1873 m)	0.1						1.1		1.3		−1.8		−8.2		−15.2				28
Fargo, N. Dak.[1] (274 m)	1.1		1.9		1.2		−1.1		−3.1		−5.2		−7.5		−12.4		−18.4		30
Kelly Field (San Antonio), Tex.[3] (206 m)	17.3		17.9		17.2		16.3		14.3		11.6		8.0		0.7		−6.2		28
Lakehurst, N. J.[4] (3 m)	5.3		5.8		3.9		1.6		−0.5		−2.8		−4.9		−9.2		−14.2		22
Maxwell Field (Montgomery), Ala.[3] (52 m)	15.6		16.8		14.5		11.5		9.0		6.6		3.4		−2.9		−9.7		25
Mitchel Field (Hempstead, L. I.), N. Y.[3] (29 m)	6.1		6.2		3.9		1.8		−0.3		−2.6		−4.8		−10.1		−16.2		26
Murfreesboro, Tenn.[1] (174 m)	11.0		12.0		10.7		8.3		6.1		3.6		1.1		−4.9		−11.6		30
Norfolk, Va.[4] (10 m)	11.2	−0.6	10.9	−0.5	9.2	−0.1	6.8	−0.1	4.6	+0.1	2.2	+0.2	−0.4	+0.3	−5.5	+0.4	−11.1	+0.4	21
Oklahoma City, Okla.[1] (391 m)	10.8		10.9		10.6		10.7		8.9		5.9		2.3		−5.2		−13.0		29
Omaha, Nebr.[1] (300 m)	5.9	−1.0	6.4	−1.2	5.8	−1.5	4.4	−1.1	2.9	−0.4	0.9	+0.1	−2.0	0.0	−8.2	+0.1	−15.0	+0.4	30
Pearl Harbor, Territory of Hawaii[4] (6 m)																			
Pensacola, Fla.[4] (24 m)	18.8	+0.8	17.4	+0.8	16.1	+1.4	14.4	+1.8	12.6	+2.1	10.2	+2.3	7.9	+2.7	2.0	+3.3	−4.4	+3.5	25
San Diego, Calif.[4] (10 m)	13.1	−2.9	12.2	−1.2	11.7	−0.8	10.2	−0.5	8.3	−0.5	6.4	+0.3	4.7	+1.2	−0.1	+1.9	−7.3	+1.9	30
Scott Field (Belleville), Ill.[3] (135 m)	7.0		9.6		7.4		6.0		4.7		2.8		0.4		−5.5		−12.2		23
Seattle, Wash.[4] (25 m)	4.6	−5.0	5.4	−2.6	3.5	−2.0	0.6	−2.1	−2.3	−2.1	−5.0	−2.2	−7.5	−2.1	−12.8	−1.9	−19.4	−1.9	30
Selfridge Field (Mount Clemens), Mich.[3] (177 m)	3.0		4.6		2.3		0.5		−0.9		−2.3		−4.6		−10.0		−16.5		29
Spokane, Wash.[5] (596 m)	5.6				3.6		1.3		−1.8		−5.0		−8.0		−13.6		−20.1		30
Sunnyvale, Calif.[4] (10 m)	12.6	−1.7	10.8	−0.7	9.3	−1.0	7.1	−1.5	4.8	−1.7	2.1	−1.7	−1.0	−1.5	−6.9	−1.1	−13.3	−1.1	26
Washington, D. C.[4] (13 m)	9.1	−1.6	8.9	+0.1	5.6	−1.0	3.8	−1.1	2.0	−1.2	0.1	−1.7	−2.4	−2.7	−7.2	−2.5	−13.3	−2.5	23
Wright Field (Dayton), Ohio[3] (244 m)	5.7		7.1		6.3		4.2		2.2		0.3		−1.8		−6.9		−13.1		26

[1] Weather Bureau. [2] Massachusetts Institute of Technology. [3] Army. [4] Navy. [5] National Guard.

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during April 1935*—Continued

RELATIVE HUMIDITY (PERCENT)

Stations	Altitude (meters) m. s. l.																Number of observations
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Billings, Mont.	74						60		56		59		62		57		51		
Boston, Mass.	67	−3	63	−4	62	−2	58	−3	62	0	62	0	60	0	52	−2	49	−2	
Cheyenne, Wyo.	71								68		57		56		55		54		
Fargo, N. Dak.	82		77		69		68		66		63		60		52		46		
Kelly Field (San Antonio), Tex.	87		78		68		51		42		37		37		38		36		
Lakehurst, N. J.	86		70		71		72		72		68		62		51		45		
Maxwell Field (Montgomery) Ala.	83		67		65		64		56		46		44		35		29		
Mitchel Field (Hempstead, L. I.), N. Y.	75		68		65		65		64		59		58		56		51		
Murfreesboro, Tenn.	87		80		76		73		71		68		65		57		52		
Norfolk, Va.	78	+10	67	+8	66	+11	65	+12	66	+15	64	+14	58	+10	48	+10	42	+10	
Oklahoma City, Okla.	73		70		60		45		40		37		40		40		41		
Omaha, Nebr.	75	+3	71	+2	65	+3	62	+4	57	+2	55	+1	55	+3	56	+6	53	+4	
Pearl Harbor, Territory of Hawaii																			
Pensacola, Fla.	82	+3	77	+6	69	+6	62	+5	54	+ 4	51	+4	43	+1	34	−3	35	−1	
San Diego, Calif.	88	+17	81	+7	68	+7	58	+8	50	+10	43	+8	38	+8	29	+6	27	+6	
Scott Field (Belleville), Ill.	82		59		58		53		48		41		41		39		37		
Seattle, Wash.	82	+10	73	+4	69	+3	66	+3	63	+3	60	+2	57	+1	50	0	49	0	
Selfridge Field (Mount Clemens), Mich.	78		67		67		64		56		53		52		47		37		
Spokane, Wash.	66				63		61		62		65		64		53		51		
Sunnyvale, Calif.	80	+9	75	+3	67	+4	62	+7	57	+9	54	+10	51	+10	47	+10	43	+10	
Washington, D. C.	74	+9	66	+5	68	+9	68	+9	62	+4	58	+3	56	+4	50	+1	46	+1	
Wright Feild (Dayton), Ohio	82		75		71		69		68		62		56		44		42		

Observations taken about 5 a. m., 75th meridian time, except along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—The departures are based on "normals" covering the following total number of observations made during the same month in previous years, including the current year: Boston, 71; Norfolk, 121; Omaha, 119; Pensacola, 163; San Diego, 146; Seattle, 69; Sunnyvale, 57; Washington, 200.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 6 a. m. (E. S. T.) during April 1935*

[Wind from N=360°, E=90°, etc.]

Altitude (m) m. s. l.	Albuquerque, N. Mex. (1,554 m.)		Atlanta, Ga. (309 m.)		Billings, Mont. (1,088 m.)		Boston, Mass. (15 m.)		Cheyenne, Wyo. (1,873 m.)		Chicago, Ill. (192 m.)		Cincinnati, Ohio (153 m.)		Detroit, Mich. (204 m.)		Fargo, N. Dak. (274 m.)		Houston, Tex. (21 m.)		Key West, Fla. (11 m.)		Medford, Oreg. (410 m.)		Murfreesboro, Tenn. (180 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	319	1.2	292	1.6	318	2.2	353	2.2	269	2.4	24	1.9	330	1.1	23	1.7	94	1.5	120	0.9	137	1.6	321	0.5	269	0.9
500			284	4.0			338	5.1			32	2.9	6	0.3	55	3.6	128	3.5	150	3.9	150	2.2	272	0.3	254	2.0
1,000			291	5.8			340	5.0			10	2.8	288	2.8	54	3.1	167	2.8	214	2.2	206	1.6	204	0.7	250	3.4
1,500			297	6.0	279	1.7	324	6.5			315	3.6	271	5.2	347	2.1	223	1.2	288	3.2	237	2.9	186	2.2	298	4.5
2,000	273	3.1	297	6.7	250	2.3	306	9.3	261	3.7	311	5.4	282	7.7	330	4.0	253	2.5	316	6.6	238	4.1	229	3.0	298	7.2
2,500	271	5.2	293	8.8	257	3.9	304	10.5	266	6.9	301	6.0	297	7.4	340	2.7	300	3.5	308	8.3	247	4.0	247	2.9	303	7.8
3,000	271	6.9	283	9.7	280	6.1	310	13.3	281	9.8	298	7.4	295	7.3	312	7.1	323	2.5	304	7.6	265	4.3	275	3.2	306	10.5
4,000	272	10.2	267	10.0	276	6.1	288	13.4	281	11.1	295	6.2	312	6.7	306	11.7	289	7.5	313	10.4	260	6.1	297	5.3	306	6.1
5,000	266	8.7	270	11.0	266	5.9	270	15.0	306	3.6	275	5.6			304	9.1	313	10.8	296	9.6	259	9.6	251	7.1		

Altitude (m) m. s. l.	Newark, N. J. (14 m.)		Oakland, Calif. (8 m.)		Oklahoma City, Okla. (402 m.)		Omaha, Nebr. (306 m.)		Pearl Harbor, Territory of Hawaii [1] (68 m.)		Pensacola, Fla.[1] (24 m.)		St. Louis, Mo. (170 m.)		Salt Lake City, Utah (1,294 m.)		San Diego, Calif. (15 m.)		Sault Ste. Marie, Mich. (198 m.)		Seattle, Wash. (14 m.)		Spokane, Wash. (603 m.)		Washington, D. C. (10 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	324	1.8	144	1.0	49	1.1	38	1.4			290	0.7	97	0.6	154	3.0	292	0.3	37	1.5	168	1.1	100	0.7	313	1.3
500	337	6.3	277	2.0	146	1.7	90	1.5			263	2.6	155	1.1			306	1.9	69	4.5	198	1.3			323	4.0
1,000	322	6.9	317	1.8	204	3.9	224	3.0			243	4.2	286	1.6			313	2.1	58	3.6	204	1.6	180	1.0	323	4.8
1,500	302	8.2	307	1.8	246	3.5	282	2.5			265	5.5	306	4.8	167	4.6	298	2.3	16	3.2	196	1.7	240	2.3	307	5.6
2,000	302	11.0	320	2.5	262	4.5	266	3.7			280	7.1	309	7.3	197	3.8	284	3.7	10	4.1	209	2.4	253	2.6	283	9.4
2,500	313	10.7	328	3.4	301	6.6	271	5.3			292	7.1	312	7.4	248	4.2	283	4.4	8	4.3	309	1.0	253	3.5	296	9.9
3,000	334	13.3	309	4.4	291	9.4	277	7.8			286	10.0	321	8.4	206	5.1	261	4.8	349	4.7	304	3.3	253	3.3	299	11.2
4,000	338	12.0	288	2.5	338	15.0	315	9.0			287	6.6	291	12.0	271	8.9	286	8.0	354	5.3	330	8.0	282	6.8	300	14.5
5,000			217	1.4											304	7.6	225	10.0	330	6.9	285	3.5	305	10.8	269	9.7

[1] Navy stations.

RIVERS AND FLOODS

[River and Flood Division, MONTROSE W. HAYES, in Charge]

By RICHMOND T. ZOCH

There were numerous floods in April, but fewer than in March. Most of them were of minor consequence; but one in Kentucky, which began in March and ended in April, was of more than ordinary importance, and the following is a report on it, made by the official in charge of the Weather Bureau office in Evansville, Ind.:

From a monetary standpoint the most disastrous flood of record in the lower Green River prevailed from March 11 to April 24, 1935. The crest at Rumsey, Ky., was 43.7 feet on April 13. In the flood of 1913 the crest at Rumsey was 47.5 feet, but due to the development of property interests in the lower Green Valley in the intervening years both the flood losses and the savings effected through heeding flood warnings were much greater in the recent flood than in the greater inundation in 1913.

At Rumsey the river is about 500 feet wide at an ordinary stage, but on April 13, the day of the flood crest, it was 14 miles wide.

McLean County was most seriously affected; about 40 percent of the county was inundated. The following towns were under water to a greater or less degree: Ashbyburg, Beech Grove, Burk City, Calhoun, Comer, Curdsville, Delaware, Eastwood, Hamilton's Ferry, Island, Jewel City, Kirtly, Lemon, Livermore, Rumsey, Sacramento, Wrightsburg. One hundred and fifteen thousand acres were inundated, of which 90,000 acres usually are cultivated, approximately as follows: 9,000 acres wheat, 18,000 acres tobacco, 31,500 acres clover, and 31,500 acres barley, lespedeza, alfalfa, corn, potatoes, tomatoes.

The first flood warnings were issued well in advance and were widely disseminated. Final crest warnings were issued 5 days in advance and in all instances were within a few tenths of the actual crests recorded. Immediately upon receipt of the warnings, action to move or protect property was taken, and there was no loss of life as a direct result of the flood. Total savings reported were $521,400.

The most outstanding case was in Livermore, Ky., where equipment in two chair factories valued at $250,000 was raised above the predicted crest, and was not harmed, although the factory buildings were flooded to a depth of 4 feet.

From conservative estimates the total loss of nonmovable property amounted to $458,150.

A report on the flood in the Sacramento River in California appears as a separate article in this REVIEW (pp. 135).

Any important features of the floods now prevailing in the lower Mississippi Basin will be mentioned in a later issue of the MONTHLY WEATHER REVIEW.

Table of flood stages in April 1935

[All dates in April unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE	*Feet*			*Feet*	
James:					
Columbia, Va.	10	1	16	22.3	2
				21.4	9
Richmond, Va.	8	2	4	12.1	3
		8	10	11.7	9
Roanoke:					
Randolph, Va.	18	2	3	23.5	3
		9	10	22.5	9
Weldon, N. C.	31	2	5	36.6	4
		9	11	36.2	10
Williamston, N. C.	10	Mar. 19	29	11.9	8–15
Tar:					
Rocky Mount, N. C.	8	3	5	8.4	4
		24	25	8.3	25
Tarboro, N. C.	18	6	6	18.2	6
Greenville, N. C.	12	Mar. 29	16	14.3	8
		27	28	12.4	27, 28
Neuse:					
Neuse, N. C.	13	2	5	16.0	4
		9	11	15.3	11
		23	25	15.3	24
Smithfield, N. C.	12	2	6	15.0	5, 6
		9	13	14.5	11, 12
		24	26	14.0	25, 26
Cape Fear: Lock No. 2, Elizabethtown, N. C.	20	2	5	24.2	3
		9	12	24.3	10
		23	25	23.5	24
Peedee:					
Mars Bluff Bridge, S. C.	17	Mar. 29	14	19.9	1
Poston, S. C.	18	3	10	19.6	5
		13	15	18.9	14
Saluda: Chappells, S. C.	13	7	7	14.9	7
Catawba: Catawba, S. C.	11	1	1	11.0	1
Santee:					
Rimini, S. C.	12	4	13	13.7	10
Ferguson, S. C.	12	4	18	13.3	11–13
Savannah: Ellenton, S. C.	14	6	15	18.0	10
EAST GULF OF MEXICO DRAINAGE					
Black Warrior: Lock No. 10, Tuscaloosa, Ala.	46	1	1	47.1	1
Tombigbee:					
Lock No. 4, Demopolis, Ala.	39	3	17	46.4	13
Lock No. 3, Ala.	33	Mar. 6	19	49.0	13
Lock No. 2, Ala.	46	5	7	46.3	6
		12	18	50.5	13
Lock No. 1, Ala.	31	Mar. 6	21	35.7	16
Pearl:					
Edinburg, Miss.	20	11	16	22.0	14
Jackson, Miss.	18	2	26	27.8	18, 19
Pearl River, La.	12	Mar. 9	(1)	16.2	Mar. 22
				14.7	23
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Illinois:					
Havana, Ill.	14	Feb. 26	26	16.1	Mar. 28–31
Beardstown, Ill.	14	Feb. 27	27	16.6	Mar. 17–20
Mississippi:					
Keokuk, Iowa	12	11	12	12.3	11
Quincy, Ill.	14	12	12	14.1	12
Hannibal, Mo.	13	10	14	13.9	12
Ohio Basin					
Gauley: Summersville, W. Va.	10	2	2	10.4	2
Barren: Bowling Green, Ky.	20	1	3	22.4	2
		7	10	23.6	9
Green:					
Lock No. 6, Brownsville, Ky.	28	1	12	36.5	9
Lock No. 4, Woodbury, Ky.	33	Mar. 27	14	44.2	10
Lock No. 2, Rumsey, Ky.	34	Mar. 12	23	43.7	13
Cumberland:					9
Celina, Tenn.	28	Mar. 26	4	40.4	Mar. 20
		6	12	40.5	18
Carthage, Tenn.	40	8	9	40.8	9
Nashville, Tenn.	40	7	13	42.3	18
Clarksville, Tenn.	46	6	14	50.5	1
Lock F, Eddyville, Ky.	50	Mar. 31	18	50.7	12
North Fork: Mendota, Va.	8	1	2	9.2	7
Elk: Fayetteville, Tenn.	14	6	8	15.5	7
Duck: Columbia, Tenn.	30	7	7	30.8	8
Tennessee:					
Bridgeport, Ala.	18	7	9	19.7	
Widow's Bar Dam, Ala.	26	7	10	28.2	8
Guntersville, Ala.	25	8	11	27.3	9, 10
Riverton Lock, Ala.	33	2	2	33.0	2
		8	12	34.0	10
Ohio:					
Dam No. 47, Newburgh, Ind.	38	Mar. 29	17	41.4	2–14
Evansville, Ind.	35	Mar. 28	18	39.3	2
				39.6	14
Dam No. 48, near Henderson, Ky.	38	Mar. 31	17	40.7	2, 3, 14, 15
Dam No. 49, near Uniontown, Ky.	37	Mar. 30	18	39.7	3
				39.1	15
Dam No. 50, Fords Ferry, Ky.	34	Mar. 13	22	42.4	4
				41.9	15, 16
Dam No. 51, Golconda, Ill.	40	2	18	41.2	7
				40.9	16
Dam No. 52, Brookport, Ill.	37	Mar. 13	21	44.8	8
Dam No. 53, near Mound City, Ill.	42	Mar. 12	22	50.0	14, 15
Cairo, Ill.	40	Mar. 12	23	48.2	14, 15
White Basin					
Black: Black Rock, Ark.	14	Mar. 11	16	28.7	Mar. 12
White:					
Georgetown, Ark.	21	Mar. 13	20	31.3	Mar. 18
Clarendon, Ark.	26	Mar. 16	29	33.7	Mar. 26
Arkansas Basin					
Petit Jean: Danville, Ark.	20	20	24	22.15	21
Red Basin					
Ouachita: Camden, Ark.	20	8	11	28.11	9
Sulphur:					
Ringo Crossing, Tex.	20	6	6	20.5	6
		21	(1)	24.4	22
Naples, Tex.	22	25	(1)	(1)	(1)

Table of flood stages in April 1935—Continued

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
MISSISSIPPI—continued					
Lower Mississippi Basin					
	Feet			*Feet*	
Big Lake Outlet: Manila, Ark.	10	Mar. 10	May 1	17.6	6,7
St. Francis:					
Fisk, Mo.	20	1	4	22.3	3
St. Francis, Ark.	18	Mar. 11	16	20.4	5
St. Francis Lake Lock, Ark.	27	Mar. 21	9	29.2	Mar. 25-27
Parkin, Ark.	28	Mar. 30	13	29.1	7,8
Madison, Ark.	32	Mar. 29	16	33.4	2-4
Tallahatchie: Swan Lake, Miss.	20	Jan. 10	(1)	29.6	17
Yazoo: Yazoo City, Miss.	29	Mar. 5	(1)	36.3	11
Mississippi:					
New Madrid, Mo.	34	Mar. 13	23	38.4	15-17
Memphis, Tenn.	34	Mar. 21	25	36.1	15-20
Helena, Ark.	39	Mar. 18	(1)	49.2	2
Arkansas City, Ark.	42	Mar. 22	(1)	51.8	6
Greenville, Miss.	36	Mar. 23	(1)	45.5	6,7
Vicksburg, Miss.	43	1	(1)	46.7	15
Natchez, Miss.	46	2	(1)	50.3	17-24
Angola, La.	45	5	(1)	48.0	20-27
Baton Rouge, La.	35	6	(1)	38.3	21, 22
Plaquemine, La.	31	6	(1)	34.2	23, 24

[1] Continued into May.

Table of flood stages in April 1935—Continued

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
MISSISSIPPI—continued					
Lower Mississippi Basin—Continued					
Mississippi—Continued.	*Feet*			*Feet*	
Donaldsonville, La.	28	7	(1)	30.0	25-27
Reserve, La.	22	9	(1)	23.0	27-29
New Orleans, La.	17	20	20	17.0	20
		22	22	17.0	22
		27	30	17.0	27-30
Atchafalaya Basin					
Atchafalaya:					
Melville, La.	37	6	(1)	(1)	(1)
Atchafalaya, La.	22	Mar. 15	(1)	24.3	20-30
PACIFIC SLOPE DRAINAGE					
Kings: Piedra, Calif.	10	8	8	10.1	8
Sacramento:					
Red Bluff, Calif.	23	8	8	23.65	8
Colusa, Calif.	25	10	10	25.55	10
Knights Landing, Calif.	30	9	11	30.2	10
Sacramento, Calif.	27	8	9	28.6	8

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, W. F. McDONALD, in Charge]

NORTH ATLANTIC OCEAN, APRIL 1935

By H. C. HUNTER

Atmospheric pressure.—April pressure averaged below normal over most of the North Atlantic Ocean. In parts of the southeastern and northeastern areas, however, the pressure was above normal, particularly near Iceland, where Reykjavik showed a mean excess of 0.19 inch.

The highest pressure thus far reported is 30.48 inches by the Swedish steamship *Braheholm*, when near latitude 57° N., longitude 20° W., shortly before noon on the 2d. The lowest reading, 28.37 inches, was noted on the American steamship *Steelmaker*, near 49° N., 32° W., during the forenoon of the 8th.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, April 1935*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.89		30.32	18	29.46	30
Reykjavik, Iceland	29.99	+0.19	30.44	2	29.61	15
Lerwick, Shetland Islands	29.75	−.05	30.34	26	28.84	11
Valencia, Ireland	29.82	−.07	30.35	28, 29	29.01	10
Lisbon, Portugal	30.11	+.12	30.34	13	29.88	27
Madeira	30.08	+.07	30.28	12	29.74	4
Horta, Azores	30.01	−.14	30.26	17	29.74	9
Belle Isle, Newfoundland	29.71	−.08	30.42	10	28.90	4
Halifax, Nova Scotia	29.90	−.03	30.36	9, 11, 12	29.54	17, 28
Nantucket	29.84	−.13	30.26	4	29.36	16
Hatteras	29.88	−.13	30.18	26	29.48	21
Bermuda	29.94	−.15	30.16	28	29.70	11
Turks Island	29.99	−.03	30.07	1, 2	29.91	22
Key West	29.96	−.06	30.18	14	29.81	7
New Orleans	29.94	−.06	30.24	14	29.68	7

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observations, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—During the period from the 7th to 16th, there was considerable storminess; otherwise there were few gales worth noting.

On the 3d the Dutch motorship *Manoeran* met two vigorous squalls, not quite an hour apart, in the north-central Gulf of Mexico.

Near the Strait of Belle Isle, on the 6th, a well-developed LOW had begun to cause gales, and this center continued rather intense as it crossed the ocean to the vicinity of Ireland, by the 10th. The sole instance of hurricane force (12) was recorded during the night of the 7th–8th, by the British steamer *Lustrous* near 45° N., 34° W. A few hours later the lowest pressure of the month was noted by the *Steelmaker* in this vicinity as mentioned above.

Another LOW, less intense, was northeast of Bermuda on the 11th and 12th, when fresh to whole gales were reported over a considerable area, mainly in latitudes lower than those where the strength of the earlier storm had been felt.

Still another LOW caused gales near the middle coast of the United States on the 15th and 16th. The fortnight of April subsequent to this was mainly without strong gales, particularly the final week.

Fog.—Fog increased somewhat from the previous month over much of the North Atlantic, particularly in the vicinity of the Grand Banks and thence eastward along the chief lanes toward northern Europe to about the 20th meridian. On the other hand fog was less frequently met in the waters just southeastward of Nova Scotia and Maine.

The square from 40° to 45° N., 45° to 50° W., with fog on 13 days, leads all other squares in fog frequency. This is somewhat more than even the Grand Banks area shows in April, on the average. The period from the 15th to the 22d was especially marked in this area for prevalence of fog.

Near the east coast of the United States the square from 35° to 40° N., 70° to 75° W., reported a notably large amount of fog, 10 days in all, or almost twice as much as normal.

Dust.—Over much of the Gulf of Mexico and off the southeast coast of the United States dust was encountered during part of the second week of April in sufficient amount greatly to reduce visibility, in a few instances to about a mile. The wind at the time was usually blowing from points between northwest and north, but in one instance from the southwest. This report was from the

vessel in the most northern position of those reporting dust off the coast of the South Atlantic States. Dust was most frequently encountered on the 12th, but near the coast of Louisiana and eastern Texas the dust set in during the 11th, while in the central Gulf and off the South Atlantic coast the dust continued into the 13th. There was a very perceptible deposit on the decks and exposed structures of most of the vessels reporting dusty atmosphere.

SEVERE STORM IN SOUTH ATLANTIC

A report has come from British motorship *Alynbank* of a prolonged, intense storm met on the voyage from Bahia Blanca to Magellan Strait. During the evening of April 18 a southwest wind increased to gale force, and continued to grow stronger till noon of the 19th when it reached force 12 with the barometer at its lowest, 29.35 inches, the position being about 7 miles east-northeast of Cape Virgins light. The afternoon and evening of the 19th brought a slight abatement. In the early hours of the 20th, with the vessel far in the strait, the force fell to 5 and the direction turned to south-southwest.

OCEAN GALES AND STORMS, APRIL 1935

Vessel	Voyage		Position at time of lowest barometer		Gale began April—	Time of lowest barometer April—	Gale ended April—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Manoeran, Du. M. S.	Cristobal	New Orleans	24 12 N.	86 24 W.	3	6p, 2	3	29.92	W	SE, 3	NNW	W, 9	
Exarch, Am. S. S.	Casablanca	New York	35 47 N.	22 05 W.	3	Noon, 3	3	29.87	NW	NW, 7	NNW	NW, 8	W-NW.
Pontchartrain, U. S. C. G.	On ice patrol out from Halifax.		44 58 N.	48 07 W.	3	5p, 3	4	29.45	WSW	WSW, 7	W	WSW, 9	None.
Siamese Prince, Br. M. S.	Gibraltar	Halifax	41 06 N.	50 05 W.	6	3a, 7	7	29.26	SW	SSW, 10	NW	SSW, 10	S-SSW-NNW.
Boston, City, Br. S. S.	Fowey	Portland, Maine	44 01 N.	43 14 W.	7	9a, 7	7	28.93	S	WSW, 9	W	WSW, 10	S-WSW-W.
Cottica, Du. S. S.	Port au Prince	New York	36 54 N.	74 36 W.	7	Noon, 7	8	29.75	ENE	ENE, 7	ENE	ENE, 10	W-N-ENE.
Sarcoxie, Am. S. S.	Bordeaux	do	45 10 N.	36 50 W.	7	5p, 7	8	29.11	SW	W, 10	NNW	W, 11	SW-W.
Lustrous, Br. S. S.	Port Arthur	Liverpool	45 00 N.	34 22 W.	7	Mdt. 7	8	29.14	W	W, 12	WNW	W, 12	None.
Pres. Roosevelt, Am. S.S.	Cobh	New York	47 48 N.	30 42 W.	8	10a, 8	9	28.69	SSW	SSW, 10	NW	SSW, 10	SSW-NW.
Steelmaker, Am. S. S.	Swansea	Portland, Maine	49 17 N.	31 52 W.	7	11a, 8	9	28.37	SE	SE, 4	NNW	SSE, 9	S-SE-N.
Pres. Harding, Am. S. S.	New York	Cobh	46 50 N.	32 20 W.	7	Noon, 8	9	28.77	S	WSW, 11	W	WSW, 11	None.
Aldecoa, Span. S. S.	Ceuta	Philadelphia	33 15 N.	32 52 W.	8	4p, 8	9	30.00	NW	SW, 4	NW	NW, 8	SW-NW.
Vistula, Am. M. S.	Oslo	New Orleans	45 20 N.	26 00 W.	8	4a, 9	11	29.19	WSW	WSW, 11	WNW	WSW, 11	None.
Mahsud, Br. S. S.	Boston	London	48 50 N.	20 00 W.	8	4p, 9	10	29.08	SW	WSW, 7	SW	SW, 10	None.
Boston City, Br. S. S.	Fowey	Portland, Maine	42 21 N.	56 11 W.	10	3a, 11	12	30.05	ENE	ENE, 8	ENE	ENE, 10	Steady.
Vistula, Am. M. S.	Oslo	New Orleans	41 15 N.	40 09 W.	12	9a, 12	14	29.80	NE	NE, 6	NE	NE, 10	None.
Aldecoa, Span. S. S.	Ceuta	Philadelphia	33 25 N.	50 06 W.	12	3p, 12	12	29.65	WSW	WSW, 8	N	WSW, 8	WSW-N.
Waukegan, Am. S. S.	New York	Havre	40 16 N.	64 07 W.	13	4p, 13	15	29.78	ESE	SSE, 8	S	S, 9	ESE-S.
Badjestan, Br. S. S.	Dantzig	Montreal	57 39 N.	20 00 W.	15	11a, 15	16	29.30	NNW	NNW, 7	NNW	NNW, 8	ENE-NNW.
Chester Sun, Am. M. S.	Smiths Bluff, Tex.	Philadelphia	34 05 N.	76 00 W.	15	4p, 15	15	29.21	NW	SW, 7	NW	NW, 8	SW-NW.
Tolon, Am. S. S.	Kingston	New York	33 05 N.	74 55 W.	16	2a, 16	16	29.67	WSW	W, 8	W	W, 8	WSW-W.
Gulfwing, Am. M. S.	Las Piedras	Philadelphia	34 46 N.	75 06 W.	15	7a, 16	16	29.57	SW	N, 7	N	NW, 9	NW-N-NW.
Black Gull, Am. S. S.	Rotterdam	New York	49 45 N.	14 48 W.	16	8a, 16	17	29.54	W	W, 9	NW	W, 10	None.
Executive, Am. S. S.	Casablanca	do	36 34 N.	57 08 W.	19	8a, 19	19	29.72	W	SW, 6	W	W, 9	SW-W.
Pres. Harding, Am. S. S.	Cobh	do	51 25 N.	9 16 W.	20	Noon, 20	21	29.37	NNW	ESE, 3	N	NNW, 10	ESE-N.
Do	do	do	44 04 N.	41 20 W.	23	4p, 23	24	29.18	WNW	NW, 7	W	W, 9	SE-NW-W.
American Banker, Am. S. S.	London	do	45 35 N.	36 06 W.	23	11p, 23	23	29.23	SW	SW, 7	WSW	SW, 8	SE-S-W.
City of Hamburg, Am. S. S.	Havre	Norfolk	42 08 N.	43 01 W.	27	6a, 27	27	29.32	NW	NW, 8	WNW	NW, 8	SSW-NW-WNW
NORTH PACIFIC OCEAN													
Golden Tide, Am. S. S.	Manila	San Francisco	39 25 N.	163 15 E.	1	6a, 2	2	29.48	SE	S, 7	S	SE, 9	SE-S-SW.
Tokai Maru, Jap. M. S.	Yokohama	Los Angeles	44 18 N.	166 08 E.	2	11p, 2	2	28.83	E	SW, 6	SW	SW, 8	E-SW.
New Westminster City, Br. S. S.	Moji	Vancouver	49 45 N.	173 10 W.	2	2a, 3	3	[1]29.43	SSE	SSE, 9	SSE	SSE, 9	Steady.
Pres. Jackson, Am. S. S.	Victoria, B. C.	Yokohama	52 08 N.	169 00 W.	3	4p, 3	4	29.85	WSW	S, 7	S	SW, 9	S-WSW.
Silverhazel, Br. M. S.	Manila	Los Angeles	35 56 N.	142 30 W.	4	5p, 4	5	29.48	ESE	E, 6	ESE	ESE, 9	
Athelchief, Br. M. S.	Los Angeles	Yokohama	34 27 N.	146 52 E.	5	11p, 5	6	29.60	SSE	S, 9	SW	S, 9	SE-S-W.
Golden Peak, Am. S. S.	Otaru	San Francisco	42 12 N.	148 48 E.	6	10a, 6	6	29.01	W	W, 8	W	NW, 9	E-W-NW.
Pres. Jackson, Am. S. S.	Victoria, B. C.	Yokohama	48 05 N.	163 15 E.	7	6p, 7	8	29.47	SE	SW, 9	WNW	SSE, 11	SSE-SW-W.
Jefferson Myers, Am. S. S.	Yokohama	Los Angeles	39 45 N.	130 00 W.	7	2a, 8	8	29.77	NW	WNW, 8	NW	NW, 8	NW-WNW-NW
City of Elwood, Am. M. S.	Hong Kong	do	23 55 N.	118 35 E.	12	3a, 12	12	29.88	NE	NE, 9	NE	NE, 9	
Kentuckian, Am. S. S.	Balboa	do	16 07 N.	94 40 W.	13	4p, 13	13	29.88	NNW	NW, 8	NNE	N, 10	NNW-NW-N.
Olympia, Am. S. S.	Tacoma	Yokohama	44 24 N.	154 00 E.	13	6a, 13	13	29.40	NNW	W, 4	NW	NW, 9	SE-W-NNW.
Sanyo Maru, Jap. M. S.	Los Angeles	do	48 15 N.	163 52 W.	15	4a, 16	17	29.09	WSW	WSW, 9	W	WSW, 9	Steady.
Hiye Maru, Jap. M. S.	Yokohama	Vancouver	49 55 N.	158 06 W.	17	Noon, 16	18	29.01	W	WSW, 7	WSW	WSW, 8	None.
Yayoi Maru, Jap. S. S.	Milke, Japan	Port Townsend	45 32 N.	163 10 E.	17	3a, 17	18	29.20	S	S, 8	WNW	W, 10	2 points.
Shelton, Am. S. S.	Tacoma	Yokohama	52 50 N.	146 38 W.	17	9a, 17	18	28.97	W	SW, 7	W	W, 10	S-WSW-W.
Tymeric, Br. S. S.	Muroran	Portland, Oreg.	47 00 N.	163 50 E.	16	10a, 17	19	29.27	SSE	SSW, 9	WNW	W, 10	S-SSW.
Do	do	do	47 16 N.	177 05 W.	21	9a, 21	21	29.32	WSW	WSW, 8	W	W, 9	SW-W.
Do	do	do	47 38 N.	171 45 W.	21	2a, 22	22	28.83	ENE	NE, 11	NW	E, 12	E-NE-NNW.
Peter Maersk, Dan. M. S.	Los Angeles	Yokohama	40 00 N.	175 20 E.	27	4p, 27	29	29.36	SE	SSW, 7	NW	NW, 10	SSE-SSW-WNW.

[1] Barometer uncorrected.

NORTH PACIFIC OCEAN, APRIL 1935

By WILLIS E. HURD

Atmospheric pressure.—The average pressure situation over the North Pacific Ocean during April 1935, showed a fairly well developed low-pressure belt overlying southwestern Alaskan waters and the neighborhood of the Aleutian Islands; a high-pressure belt extending from southeastern Alaska southward to middle latitudes and thence westward into east longitudes, with the crest near Midway Island; and a shallow tropical low-pressure belt, which was of pronounced depth over the southwestern part of the ocean.

Pressures were decidedly above the normal in the northern Pacific, where strong anticyclones prevailed early and late in the month, and below the normal in waters of California and in the tropics.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, April 1935, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	30.30	+0.21	30.86	12	29.94	23
Dutch Harbor	29.85	+.07	30.60	26	28.84	15
St. Paul	29.97	+.18	30.86	27	29.14	15
Kodiak	29.83	+.08	30.66	27	28.90	16
Juneau	29.99	+.03	30.70	26	29.32	18
Tatoosh Island	30.00	.00	30.43	25	29.47	22
San Francisco	29.97	−.08	30.22	6	29.44	7
Mazatlan	29.87	−.02	29.96	2	29.80	12
Honolulu	30.06	.00	30.14	28	29.91	1
Midway Island	30.13	+.01	30.30	7, 16	29.84	28
Guam	29.81	−.08	29.86	21	29.76	28
Manila	29.79	−.03	29.84	1, 15, 16, 20, 21, 22	29.72	5, 6
Hong Kong	29.83		30.07	1	29.67	9
Naha	29.90	−.02	30.12	1	29.74	28
Chichishima	29.97	.00	30.14	3	29.68	19
Nemuro	29.94		30.36	8	28.92	30

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Cyclones and gales.—Storm conditions decreased materially over the North Pacific from March to April. No deep cyclones entered the western part of the ocean from Asia until the end of the month, when a storm with pressure readings below 29 inches crossed northern Japan on the 30th, accompanied by a strong gale on the south coast of Hokushu. Several cyclones of moderate intensity in immediate Japanese waters developed considerably in strength over the ocean in their passage toward Aleutian waters. This was particularly true of the Hokushu LOW of April 5, which caused fresh to strong gales to the eastward on the 6th, and a gale of force 11 near 48° N. 163° E., on the 7th. Another depression, which left Japan on the 11th, caused fresh to strong gales as far to the eastward as 165° E. on the 12th to 14th.

Gales to the southward of the Aleutian Islands, between 40° and 50° N. 170° E. and 150° W., resulted from the activities of the great low-pressure system in these waters. On several days scattered gales in this regior did not exceed 8 in force, but on the 3d, 4th, 16th, 18th, 21st, 22d, 23d, and 29th, forces of 9 to 10, likewise scattered as to distribution, occurred.

On the 22d the severest extra-tropical gale of the month, of force 12 from the east, was reported by the British steamship *Tymeric* near latitude 47° N. longitude 172° W. This ship encountered much rough weather on the 21st–23d, during an eastbound voyage to Portland, and was forced on several occasions to heave to on account of the strong winds and high seas. Her lowest corrected barometer on the 22d was 28.83 inches, which, with an identical reading reported by the Japanese motorship *Tokai Maru* near 44° N. 166° E. on the 2d, was the lowest pressure reading of the month outside of the tropics. The lowest land reading in high latitudes was 28.84 inches, at Dutch Harbor on the 15th.

Between 150° W. and the American coast few gales occurred and these principally in connection with moderate disturbances on the California-Hawaiian routes during the early half of the month.

Typhoon.—One small typhoon crossed the Philippines early in the month, causing considerable loss of life and property damage on the island of Samar. The lowest pressure reported was 27.97 inches, accompanied by hurricane winds, at Borongon. A history of the disturbance will be found in the subjoined report by the Rev. B. F. Doucette.

Tehuantepecer.—On the 13th a norther gale, force 10, was encountered by the American steamer *Kentuckian* in the Gulf of Tehuantepec. In an observation from Vera Cruz, on the Mexican east coast, a north gale of force 9 was reported on the same date.

Fog.—Along most of the American coast fog increased materially from March to April. It occurred on 10 days between Cape Blanco and Point Conception, and on 6 days between San Diego and Cape Corrientes. Occasional fog was met with along the northern steamship routes, with the region of greatest frequency—2 or 3 days in each 5° square—between 165° E. and the northern half of the Japanese coast.

TYPHOON OVER THE FAR EAST, APRIL 1–9, 1935

BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

In the early part of April 1935 a small yet intense typhoon appeared over the Western Caroline Islands and moved toward the Philippines. It passed over the Island of Samar, leaving a narrow path in which severe destruction was experienced, and moved on a northwest course to Central Luzon, weakening as it crossed this island on its way to the China Sea. As the barometric minimum at Borongon showed, the typhoon was well developed and very deep, although small in area.

The approximate positions determined after data from ships had been copied and complete records had been received from stations along the course of the typhoon, are given below.

	Latitude		Longitude	
	°	′	°	′
April 1, 2 p. m.	About 200 miles ESE. of Yap			
April 2, 6 a. m.	10		139	
April 3, 6 a. m.	11	30	135	
April 4, 6 a. m.	12	30	131	30
April 5, 6 a. m.	13	00	130	
April 6, 6 a. m.	11	30	125	30
April 7, 6 a. m.	13	30	122	10
April 8, 6 a. m.	16	30	119	
April 9, 6 a. m.	20	00	119	

Forming ESE. of Yap, the typhoon moved WNW. for 3 days, decreasing its speed as it proceeded. It began to move more rapidly during the night of April 5, inclining to the WSW. The morning of the 6th found it over the Island of Samar, between Borongon and Guiuan, two stations on the eastern coast, and very close to the former station. It now changed to a NW. course, passing over Catbalogan and Calbayog, two stations on the western coast of Samar, the calm area being experienced at Catbalogan. Over the western portion of San Bernardino

Strait, the storm remained stationary or moved very, very slowly, for many hours during the day (Apr. 6); then during the night it moved to a position between the Island of Marinduque and Bondoc Peninsular (Apr. 7, 6 a. m.). It now moved slowly to a position between Infanta, Tayabas, and Manila (Apr. 7, 2 p. m.), passing close to and south of Infanta and beginning to weaken. It continued on this NW. course, crossing Central Luzon and entering the China Sea as a depression.

A few remarks are in order concerning the positions given for April 4 and 5. These are based upon a few ships' reports copied from their logs upon arrival at Manila. Judging by the observations made at Borongon and Guiuan, the typhoon approached these stations on a westerly course, indicating that the positions given above may be too far north.

The barometric minima recorded by Weather Bureau stations near the track of the typhoon are of interest. Borongon recorded the low minimum of 710.38 mm (27.968 in.) with winds of force 12 from the N., April 6, 6 a. m. Guiuan had 739.28 mm (29.106 in.) with winds of force 9 from the WSW., April 6, 6:30 a. m. Infanta, Tayabas had a minimum of 748.84 mm (29.482 in.) with winds of force 10 from the NE., April 7 at 1:50 p. m. Three hours later, however, the wind was only force 6 and from the SSW., an indication of the rapid decrease in intensity of the typhoon as it was moving into Central Luzon. At Catbalogan and Calbayog, instruments and records were lost, due to the intense winds, and no dependable values of the pressure at those locations are available.

Concerning the loss of life, there were 37 dead in Samar, 22 in Tayabas Province, and 1 in Sorsogon Province, according to official reports. Besides the total of 60 given above, an uncertain number of fishermen from the town of Guinayangan, Tayabas, were lost. The Manila newspapers, April 11, reported that 100 fishermen had set out over the northern part of Ragay Gulf during the night of April 6 and, of this number, only 17 bodies, washed up on the shore could be found. Then, an unofficial report given out by the papers, April 15, stated that 16 fishing boats manned by 78 men were caught by the typhoon. Of these men, 58 were accounted for and only 20 were missing. Further investigation is required for an accurate report. The property loss consisted of extensive destruction to light-material houses and considerable damage to strong-material buildings. The town of San Narciso, on the eastern coast of Bondoc Peninsula, was practically ruined. The mail boat at San Narciso, was thrown upon the shore. Along the course of the typhoon, up to the point where it began to weaken, rice and coconut crops suffered.

There are some aspects connected with this typhoon which may be of interest to readers of the MONTHLY WEATHER REVIEW. On April 4 and 5, the typhoon was over the ocean, moving slowly toward the archipelago. It increased its speed just as an anticyclone to the north increased in intensity, and approached the Island of Samar quite rapidly. Once the typhoon was over the archipelago, it could be seen that there was no extensive current of Southwest Monsoon air. While the typhoon was situated over the western portion of San Bernardino Strait (Apr. 6) between Masbate Island and Sorsogon Province, Surigao, Cebu and Iloilo reported SW. winds (the typhoon being 120 to 150 miles away). Judging from data available at the present writing, this current of air apparently did not extend any further to the southwest.

902—35——4

During the few days preceding the appearance of the typhoon, the pilot-balloon-ascension reports received by radio from the United States naval station at Guam have some points of interest. The 6 a. m. ascents show that the air currents were from the ENE. on March 30 at velocities of 8 and 9 m. p. s. up to 3,000 meters, then decreasing aloft. On March 31, however, the direction remaining practically ENE., there is an increase of velocity of the air stream (12 m. p. s.) with indications of stratification; that is, an increase and decrease and then increase of velocity with altitude. On April 1, the velocity remains the same as the preceding day, but the direction is shifting to the ESE. at 1,500 meters. On April 2, with velocity remaining the same, the current of air is now from the SE. up to 3,000 meters. Rain prevented an ascent on the 3d. During the afternoon of April 1, the typhoon was forming about 400 miles SSW. of the station.

At Manila, through the kindness of United States Army officials at Nichols Field and at Fort Mills, the writer obtained the records of morning ascents from April 1 to 5, showing the air currents over Manila as the typhoon approached Samar Island, which is about 300 miles southeast of the city. The pilot-balloon data show an ENE. current aloft varying irregularly in intensity. On April 3, 7 a. m., this ENE. current increased from 5 m. p. h. to 20 m. p. h. up to 1,500 meters, then decreased to 9 m. p. h. at 2,500 meters, then increased to 19 m. p. h. at 4,000 meters. The typhoon was, at this time, about 900 miles to the ESE. of Manila. On April 4, there were ENE. and NE. winds aloft, steadily increasing with altitude to 24 m. p. h. at 2,500 meters, and then decreasing to 12 m. p. h. at 3,500 meters and then increasing to 20 m. p. h. at 4,500 meters, the typhoon now being about 600 miles ESE. of the city. On April 5, when the typhoon was about 500 miles away from the city, the ascent is almost a duplicate of that of the preceding day, except that the velocities at 4,500 meters are weaker. After studying records of ascents made during the latter part of 1934 at Guam and at Manila, a period when typhoons formed frequently and moved rapidly, the writer has received the impression that this stratified condition of the atmosphere as manifested in pilot-balloon ascension reports, may be used in forecasting the progress of the typhoon as well as for giving information concerning its structure.

SEA-SURFACE TEMPERATURE SUMMARY FOR THE NORTHWESTERN GULF OF MEXICO, 1912–33

By GILES SLOCUM

The monthly mean sea-surface temperatures in a representative area in the northwestern quadrant of the Gulf of Mexico are given in the accompanying table. The period covered is from January 1912 to December 1933, inclusive. There are 2 months, as noted in the table, for which no observational data are available. The observations of sea-surface temperatures for the years 1917, 1918, and 1919 are few in number, and the average temperatures are given to whole degrees for these years. For the other years, with a larger number of observations, the mean values are given to tenths of a degree.

The area in which these temperature observations were taken embraces six 1° squares, namely, between 90° W. and 93° W. and between 27° N. and 29° N.

Monthly and annual mean sea-surface temperatures in the northwestern Gulf of Mexico, 1912–33, inclusive

Year	Total number of observations for the year	January	February	March	April	May	June	July	August	September	October	November	December	Annual [1]
1912	326	67.2	64.0	67.2	70.4	75.8	78.8	82.5	84.3	83.2	80.2	74.0	69.3	74.7
1913	267	69.6	68.0	67.3	71.3	75.2	79.2	81.8	82.6	82.1	78.9	73.4	71.3	75.1
1914	225	67.9	67.1	66.8	71.2	76.3	81.1	83.8	84.6	82.3	77.9	74.0	70.0	75.2
1915	162	65.1	65.6	62.2	65.7	75.1	80.0	83.0	83.1	82.1	78.6	75.9	70.5	73.9
1916	155	70.0	68.1	68.3	72.2	77.0	81.1	83.7	83.0	82.3	79.2	74.5	72.2	76.0
1917	102	70	72	69	70	73	80	83	83	81	79	69	71	75.1
1918	27	67	70	70	71	75	80	(2)	82	82	(2)	75	70	[3] 75.5
1919	69	63	62	67	73	76	80	83	84	82	81	76	74	75.1
1920	116	69.4	64.2	66.0	71.0	79.0	81.7	82.3	83.5	83.8	78.4	71.9	67.8	74.9
1921	293	68.2	66.1	72.1	72.9	75.8	81.3	82.0	83.4	82.8	80.6	76.9	72.0	76.2
1922	427	72.7	71.2	70.1	73.7	78.2	81.6	83.1	83.7	82.5	79.0	76.0	72.5	77.0
1923	482	68.6	66.5	68.3	71.6	75.2	80.4	81.6	82.6	82.5	80.5	73.8	70.2	75.2
1924	641	67.9	65.7	65.1	69.2	74.0	83.0	84.1	85.4	83.8	77.9	74.3	70.5	75.1
1925	675	70.2	68.6	71.5	73.7	76.8	80.6	83.4	84.4	83.5	81.4	75.7	69.6	76.6
1926	759	65.6	65.7	67.7	69.7	75.3	81.6	83.7	83.6	82.9	81.1	73.6	71.8	75.2
1927	965	68.8	71.5	70.3	74.4	76.9	81.4	84.2	84.7	83.7	79.4	76.8	72.3	77.0

Monthly and annual mean sea-surface temperatures in the northwestern Gulf of Mexico, 1912–33, inclusive—Continued

Year	Total number of observations for the year	January	February	March	April	May	June	July	August	September	October	November	December	Annual [1]
1928	886	68.5	66.9	69.6	70.4	75.3	80.3	83.3	85.3	82.7	80.6	76.0	71.1	75.8
1929	751	69.1	67.6	69.5	73.9	77.0	80.0	81.7	83.5	82.0	78.5	74.0	68.2	75.4
1930	642	66.9	66.6	66.7	70.2	75.7	79.1	83.2	83.9	81.7	79.4	74.3	69.6	74.8
1931	696	65.7	66.2	65.2	67.4	72.7	79.4	83.6	83.2	83.3	80.5	76.2	74.1	74.8
1932	684	71.4	72.2	69.6	71.9	75.1	80.4	84.4	83.8	82.4	77.8	72.4	68.6	75.8
1933	784	68.0	67.9	68.6	71.6	77.9	80.9	82.7	83.2	83.3	80.3	75.9	73.0	76.1
Number of years' record		22	22	22	22	22	22	21	22	22	21	22	22	22
Mean (1912–33)		68.2	67.4	68.1	71.2	75.8	80.5	83.1	83.7	82.6	79.6	74.6	70.9	[3] 75.5

[1] All monthly values were carried to 1 decimal place for these means, which, therefore, are not exact means of figures given here.
[2] No data.
[3] Interpolated values are used for missing months.

DUST STORMS, APRIL 1935

In some parts of the country, April 1935 was dustier than March. The region that had been popularly named the "dust bowl" had several more instances of dust than occurred the previous month. As will be seen from the chart, the number of days with dust storms or dusty conditions during April averaged well over 20 in northwestern Texas and adjacent sections. One station, Amarillo, Tex., reported dusty conditions on 28 days of the month.

An interesting feature of the distribution of the dusty conditions this month was the unusual amount reported from the extreme Southeast, particularly northwestern and western Florida. As may be deduced from the spread of the dust southeastward, there were more drifts of air in that direction.

The plate gives an excellent view of a dust storm that occurred at Spearman, Tex., on April 14, 1935. The photograph was submitted by the official in charge, Houston, Tex., and was taken by F. W. Brandt, cooperative observer at Spearman, Tex.

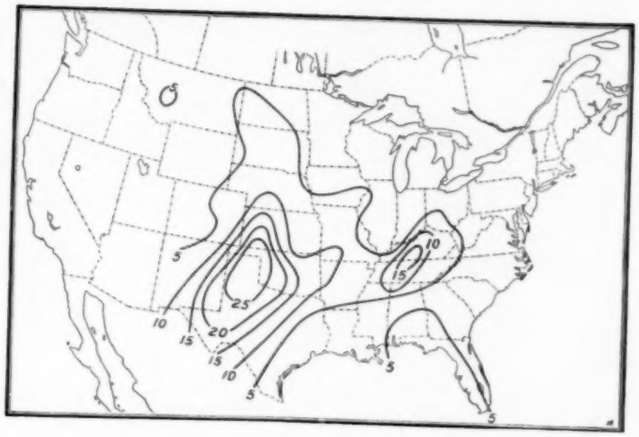
CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.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DUST STORM APPROACHING SPEARMAN, TEXAS
APRIL 14, 1935

UNIV. OF MICH.

Condensed climatological summary of temperature and precipitation by sections, April 1935

[For description of tables and charts, see REVIEW, January, p. 37]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	64.9	+1.3	Brewton	92	25	Valleyhead	30	10	5.50	+1.22	Eufaula	10.12	Camp Hill	2.73
Arizona	59.3	−1.6	Mohawk	100	14	Bright Angel R. S.	12	10	.43	−.10	Junipine	2.43	19 stations	.00
Arkansas	60.2	−1.3	Hope	90	25	4 stations	29	[1] 8	4.37	−.52	Danville	8.56	Cotter	1.47
California	54.5	−1.7	2 stations	100	[1] 20	Twin Lakes	1	9	4.70	+3.05	Scales	18.31	3 stations	.00
Colorado	43.7	+.1	Holly	88	14	Hermit (near)	−4	10	2.05	+.26	Shoshone	5.34	5 stations	T
Florida	71.7	+1.8	2 stations	96	20	Garniers	35	14	4.17	+1.31	Okeechobee	11.63	Pinellas Park	1.04
Georgia	64.8	+1.2	do	94	[1] 2	Blairsville	26	17	4.58	+.97	Flat Top	8.72	Brooklet	1.57
Idaho	43.4	−1.6	Indian Cove	80	20	Obsidian	−2	1	2.30	+.93	Council	4.53	Porthill	.06
Illinois	49.7	−2.5	McLeansboro	89	26	2 stations	22	15	2.62	−.77	Brookport	6.38	Paris	1.43
Indiana	49.6	−2.2	4 stations	90	26	Angola	19	16	2.44	−1.05	Huntingburg	3.75	Decatur	1.05
Iowa	46.7	−2.0	2 stations	86	22	West Bend	15	15	1.92	−.81	Hawarden	5.38	2 stations	.00
Kansas	52.3	−2.4	do	90	14	3 stations	20	7	1.13	−1.46	Walnut	4.46	5 stations	.00
Kentucky	55.3	−.8	Bardstown	92	26	do	24	[1] 16	4.42	+.46	Glasgow	7.14	Cold Spring	2.62
Louisiana	67.9	+.8	Melville	94	25	2 stations	35	14	6.00	+1.35	Franklinton	10.54	Atchafalaya	1.99
Maryland-Delaware	50.0	−2.4	3 stations	92	27	Oakland, Md.	14	16	3.76	+.19	Crisfield, Md.	6.25	Cumberland, Md.	2.03
Michigan	41.8	−.8	Midland	86	27	Sidnaw	0	3	1.33	−1.24	Hillsdale	3.48	East Jordan	.36
Minnesota	40.0	−3.2	Winona	78	26	Pokegama Falls	−7	3	2.38	+.32	Pipestone	4.23	Redby	.57
Mississippi	64.5	−.1	3 stations	91	[1] 25	2 stations	34	14	6.22	+1.37	Stoneville	10.02	Vicksburg	2.97
Missouri	52.3	−2.9	Lebanon	90	23	Tarkio	23	1	2.89	−.98	Poplar Bluff	6.11	Willow Springs	1.00
Montana	37.4	−5.5	Garland	85	21	Summit	−30	2	1.12	−.03	2 stations	3.09	Malta	T
Nebraska	45.7	−3.5	Culbertson	87	21	Hay Springs	8	2	3.33	+.88	Hay Springs	6.48	Superior	.49
Nevada	48.5	+.7	Logandale	94	[1] 14	San Jacinto	12	24	1.88	+1.10	Marlette Lake	7.35	Boulder City	.15
New England	43.0	−.7	Springfield, Mass.	91	28	Pittsburg, N. H.	−7	[1] 4	3.18	−.14	Pembroke, Mass.	7.65	Egremont, Mass.	1.32
New Jersey	48.7	−1.0	Runyon	91	28	2 stations	22	[1] 4	2.27	−1.34	Lakewood	4.30	Culvers Lake	1.15
New Mexico	51.9	+.3	Nara Visa (near)	98	15	Therma (near)	0	19	.56	−.33	Dulce	3.39	16 stations	.00
New York	43.1	−1.1	Port Jervis	91	27	Stillwater Reservoir	6	6	2.74	−.23	South Edwards	5.95	Buffalo	.88
North Carolina	57.1	−.8	2 stations	91	[1] 25	Mount Mitchell	12	16	4.13	+.61	Parker	7.51	Southport	1.06
North Dakota	38.4	−3.2	Towner	83	22	2 stations	0	[1] 1	1.94	+.55	Fullerton	4.77	Eckman	.35
Ohio	47.4	−2.4	Portsmouth	89	26	Bangorville	15	16	1.95	−1.17	Dam No. 28	5.01	Wooster (2)	.91
Oklahoma	58.6	−1.7	2 stations	95	14	Boise City	21	12	2.28	−1.12	Smithville	7.34	2 stations	.00
Oregon	45.8	−1.3	do	88	27	Meacham	−4	2	2.90	+.92	Wicopee	8.14	do	.41
Pennsylvania	47.1	−1.6	Carlisle	91	27	2 stations	12	16	2.56	−.88	Lancaster	4.68	Center Hall	1.13
South Carolina	62.4	+.1	3 stations	91	[1] 20	Long Creek	27	17	3.60	+.56	Long Creek	6.86	Charleston	1.12
South Dakota	41.4	−4.6	Menno	89	22	Camp Crook	−4	1	3.57	+1.41	Gannvalley	7.37	Strool (near)	.75
Tennessee	58.2	−.5	Clarksville	92	26	Elkmont	22	17	4.82	+.39	Parksville	8.28	Halls	2.74
Texas	67.1	+.9	Mission	105	6	Spearman	26	12	2.57	−.59	Flatonia	10.98	8 stations	.00
Utah	47.0	.0	St. George	87	[1] 14	Woodruff	11	11	2.05	+.86	High Line City Creek	5.91	Monticello	.31
Virginia	52.0	−2.5	Tappahannock	92	27	2 stations	12	16	4.26	+.98	Diamond Springs	6.30	Berryville	2.33
Washington	45.9	−2.1	Wind River	84	27	Bumping Lake	−3	[1] 1	1.45	−1.00	Spirit Lake	6.80	Ellensburg	.00
West Virginia	49.8	−2.0	Martinsburg	92	27	2 stations	13	16	3.45	−.06	Davis	10.62	New Cumberland	1.54
Wisconsin	41.8	−1.9	2 stations	84	26	Long Lake	4	3	2.43	−.11	Stevens Point	5.10	Solon Springs	.83
Wyoming	37.6	−2.5	Yoder	82	21	Gallatin	−17	1	1.93	+.34	Dome Lake	5.44	Powell	.32
Alaska [March]	16.3	+2.1	Haines	54	18	2 stations	−47	[1] 22	1.93	+.04	View Cove	8.64	Barrow	.09
Hawaii	69.6	−.6	Kaanapali	90	30	Kanalohuluhulu	42	[1] 5	7.32	−1.60	Puhonua	55.20	9 stations	.00
Puerto Rico	74.6	−.4	Juana Diaz	95	27	Guineo Reservoir	43	6	2.39	−2.30	Maricao	7.77	Mona Island	.00

[1] Other dates also.

TABLE I.—*Climatological data for Weather Bureau stations, April 1935*

[Compiled by Annie E. Small, by official authority, U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	°*F.*		°*F.*	°*F.*		°*F.*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							**44.0**	**+0.1**										**71**	**2.97**	**0.0**										**6.4**		
Eastport	76	67	85	29.78	29.87	−0.06	38.7	−0.3	66	28	45	20	5	32	29	35	31	77	1.87	−1.0	11	7,962	nw.	48	e.	13	9	8	13	5.9	1.0	0.0
Greenville, Maine	1,070	6	40	28.70	29.89	.....	37.4	.....	74	27	47	11	5	28	34	.....	.....	75	5.37	.....	13	4,806	nw.	31	.....	28	9	9	12	.....	12.0	.....
Portland, Maine	103	82	117	29.76	29.89	−.07	43.4	+.4	75	27	50	27	7	37	25	38	30	64	2.15	−1.2	12	6,830	n.	37	ne.	9	14	5	11	4.8	.8	.0
Concord	289	60	.....	.....	.....	.....	45.4	+2.0	85	27	53	24	4	38	36	.....	.....	.....	3.04	+.3	10	.....	nw.	.....	.....	.....	11	7	12	.....	7.7	.....
Burlington	403	11	48	29.45	29.90	−.09	41.4	−1.9	80	27	50	20	7	33	32	.....	.....	.....	3.31	+1.2	16	5,930	n.	27	se.	11	4	8	18	7.2	8.1	.0
Northfield	876	12	60	28.94	29.90	−.09	39.4	−.9	81	27	49	16	6	29	37	36	30	71	2.83	+.6	15	5,284	n.	27	n.	24	3	11	16	7.4	4.9	.0
Boston	124	336	360	29.73	29.87	−.10	45.2	−1.2	84	27	52	28	7	38	27	39	32	65	4.77	+1.4	11	11,077	w.	52	ne.	9	4	10	16	7.1	1.9	.0
Nantucket	12	14	90	29.83	29.84	−.13	43.8	+.4	60	28	49	32	7	38	19	40	37	82	3.83	+.9	14	11,284	sw.	49	ne.	9	8	9	13	6.1	1.8	.0
Block Island	26	11	46	29.82	29.85	−.13	44.2	+.2	69	28	50	31	7	39	21	41	38	81	3.03	−.5	16	12,422	w.	47	ne.	10	7	10	13	6.5	.4	.0
Providence	160	215	251	29.69	29.87	−.11	46.8	+.2	82	27	55	29	7	39	28	40	32	62	3.37	+.2	13	8,996	nw.	38	nw.	2	8	10	12	6.1	.7	.0
Hartford	159	70	104	.....	29.87	−.12	47.7	+1.0	86	27	56	29	4	40	31	.....	.....	.....	2.05	−1.3	11	7,137	nw.	.....	.....	.....	8	7	15	.....	1.2	.0
New Haven	106	74	153	29.77	29.89	−.10	48.2	+1.0	84	27	56	32	17	40	32	41	34	62	2.42	−1.1	12	7,808	n.	35	ne.	10	5	13	12	6.5	1.9	.0
Middle Atlantic States							**50.3**	**−1.2**										**68**	**3.35**	**+0.3**										**6.8**		
Albany	97	107	115	29.80	29.90	−.10	46.4	−.4	86	27	55	28	7	38	35	42	37	73	2.48	.0	15	5,769	w.	26	n.	9	5	11	14	6.0	T	.0
Binghamton	871	60	68	28.98	29.93	−.09	43.1	−2.3	86	27	52	26	16	34	46	.....	.....	.....	3.23	+.8	16	4,852	nw.	22	nw.	30	4	3	23	7.9	5.7	.0
New York	314	415	454	29.54	29.88	−.12	49.5	+.1	81	27	57	30	16	42	28	43	37	68	1.61	−1.6	12	10,899	nw.	49	nw.	15	6	11	13	6.8	T	.0
Bellefonte	1,050	5	42	28.80	29.92	.....	44.6	.....	84	27	56	20	16	33	49	39	34	72	1.72	.....	10	.....	w.	.....	.....	.....	3	9	18	7.4	7.6	.0
Harrisburg	374	94	104	29.51	29.91	−.11	49.8	−1.1	86	27	58	27	16	41	36	42	35	62	2.69	.0	10	6,102	ne.	29	nw.	30	5	12	13	6.5	1.4	.0
Philadelphia	114	168	367	29.74	29.91	−.10	51.6	−.5	83	27	59	32	16	44	32	43	35	60	2.12	−.9	9	10,270	n.	43	e.	8	4	10	16	6.8	T	.0
Reading	323	283	306	29.56	29.91	.....	50.4	+.1	86	27	58	27	16	42	30	43	34	58	2.44	−.8	10	9,112	nw.	43	nw.	30	6	12	12	6.5	T	.0
Scranton	805	72	104	29.04	29.92	−.09	46.0	−2.1	86	27	55	27	16	37	44	39	32	63	3.50	+.7	13	5,336	nw.	33	nw.	30	4	11	15	6.8	3.6	.0
Atlantic City	52	37	172	29.83	29.89	−.11	48.4	+.6	82	28	54	31	16	42	28	44	40	77	2.93	−.1	12	13,398	ne.	56	ne.	8	3	11	16	7.2	T	.0
Sandy Hook	22	10	57	29.86	29.88	.....	48.2	.....	79	27	55	32	16	42	27	43	38	72	1.85	−1.8	13	11,670	ne.	48	ne.	8	7	13	10	6.0	T	.0
Trenton	190	88	106	29.69	29.90	.....	49.6	−.2	82	27	58	30	5	41	34	43	36	66	1.46	−1.5	12	8,015	nw.	30	ne.	8	4	11	15	6.8	T	.0
Baltimore	123	100	215	29.78	29.91	−.10	52.6	−1.0	91	27	60	32	16	45	37	45	37	60	5.12	+1.8	10	8,390	ne.	38	nw.	15	7	9	14	6.5	1.0	.0
Washington	112	62	85	29.79	29.91	−.11	51.9	−1.4	89	27	61	30	16	43	37	44	37	62	3.95	+.7	13	6,014	nw.	32	nw.	15	10	7	13	6.2	T	.0
Cape Henry	18	8	54	29.87	29.89	.....	53.2	−1.4	88	27	60	38	16	47	37	48	45	80	5.64	+2.3	16	9,726	nw.	38	n.	15	6	9	15	6.7	T	.0
Lynchburg	686	5	.....	29.19	29.94	−.08	54.3	−3.0	88	27	65	32	16	43	41	.....	.....	.....	4.78	+1.8	15	.....	ne.	.....	.....	.....	3	15	12	.....	T	.0
Norfolk	91	80	125	29.81	29.91	−.10	54.7	−2.1	87	27	62	37	16	47	37	49	45	75	5.22	+2.0	15	7,784	ne.	34	n.	15	6	7	17	7.2	T	.0
Richmond	144	11	52	29.77	29.92	−.10	53.7	−2.9	87	27	63	30	16	44	40	47	41	70	4.40	+.9	15	6,573	ne.	26	w.	15	7	8	15	6.5	.2	.0
Wytheville	2,304	49	55	.....	29.90	−.13	50.0	−2.0	79	26	59	24	16	41	39	.....	.....	74	3.60	+.6	15	5,331	w.	37	w.	15	8	7	15	.....	1.1	.0
South Atlantic States							**62.1**	**+0.3**										**74**	**2.85**	**−0.2**										**5.6**		
Asheville	2,253	89	104	27.58	29.93	−.10	54.7	+.8	82	26	65	30	17	45	34	48	43	77	3.68	+.7	12	6,440	nw.	30	nw.	16	8	10	12	6.2	T	.0
Charlotte	779	63	86	29.09	29.92	−.11	59.2	−.6	84	2	68	36	8	50	29	52	47	70	4.02	+.7	12	5,255	ne.	30	sw.	15	8	10	12	6.1	.0	.0
Greensboro	886	6	56	28.98	29.94	.....	55.0	.....	83	27	65	32	17	45	33	48	44	74	3.98	.....	11	6,405	ne.	30	sw.	15	9	6	15	6.6	.0	.0
Hatteras	11	5	50	.....	29.88	−.13	57.8	−2.0	76	30	64	44	11	52	21	.....	.....	84	2.56	−1.0	11	9,720	n.	41	n.	15	10	10	10	.....	.0	.0
Raleigh	376	103	146	29.50	29.91	−.12	57.0	−2.4	86	27	66	36	8	48	33	52	48	77	2.95	−.5	15	6,328	ne.	32	nw.	15	8	9	13	6.0	.0	.0
Wilmington	72	73	107	29.84	29.91	−.12	61.6	−.4	83	19	71	38	17	52	30	55	52	76	1.89	−.8	9	7,022	nw.	32	sw.	15	12	10	8	5.2	.0	.0
Charleston	48	11	92	29.88	29.92	−.11	66.4	+1.9	88	20	74	46	9	59	23	59	55	74	1.12	−1.4	7	7,555	sw.	24	s.	15	9	10	11	5.6	.0	.0
Columbia, S. C.	351	41	57	29.54	29.92	−.11	63.3	.0	87	26	73	39	17	54	32	56	51	70	2.30	−.6	11	5,072	w.	32	sw.	15	9	8	13	5.5	.0	.0
Greenville, S. C.	1,039	139	.....	.....	.....	.....	60.0	+1.4	85	20	69	36	8	51	33	.....	.....	.....	4.61	+.9	14	.....	ne.	.....	.....	.....	12	4	14	.....	.0	.0
Augusta	182	62	77	29.72	29.91	−.12	64.6	+.4	88	2	74	42	9	55	32	56	51	67	2.31	−.8	11	4,533	nw.	23	w.	15	8	8	14	6.2	.0	.0
Savannah	65	73	152	29.86	29.93	−.10	68.2	+2.2	88	19	78	44	9	59	30	60	56	75	3.29	+.7	8	8,024	w.	28	sw.	15	12	9	9	4.8	.0	.0
Jacksonville	43	86	110	29.90	29.96	−.08	70.4	+1.7	89	2	80	46	14	61	28	62	58	72	2.66	+.3	7	6,194	sw.	27	w.	3	10	16	4	4.2	.0	.0
Florida Peninsula							**75.5**	**+2.4**										**74**	**3.30**	**+1.2**										**3.8**		
Key West	22	10	64	29.94	29.96	−.06	78.4	+2.7	88	7	84	65	15	72	18	71	68	74	1.64	+.4	7	6,332	se.	24	n.	13	14	14	2	3.7	.0	.0
Miami	25	124	168	29.96	29.99	−.04	75.2	+2.4	91	30	83	53	14	68	24	68	65	73	6.23	+3.1	6	7,259	se.	29	s.	22	14	11	5	4.1	.0	.0
Tampa	35	88	197	29.93	29.97	−.09	73.0	+2.1	89	20	82	52	15	64	28	64	61	74	2.03	.0	6	7,688	w.	41	nw.	7	18	9	3	3.5	.0	.0
Titusville	43	5	36	29.91	29.96	.....	71.1	.....	93	20	83	44	14	59	37	.....	.....	.....	3.54	.....	10	.....	w.	.....	.....	.....	12	12	6	.....	.0	.0
East Gulf States							**65.6**	**+0.8**										**75**	**4.82**	**+0.6**										**5.8**		
Atlanta	1,173	128	135	28.90	29.92	−.11	61.2	+.2	85	26	71	39	14	52	32	54	50	76	4.27	+.7	16	6,120	nw.	27	nw.	15	5	7	18	7.1	.0	.0
Macon	370	79	87	29.54	29.93	−.10	64.8	+.9	88	2	75	41	17	55	32	57	52	68	3.17	.0	12	4,920	nw.	21	sw.	7	9	10	11	5.5	.0	.0
Thomasville	273	49	58	29.68	29.97	−.06	67.3	+.6	88	2	78	40	9	57	29	61	58	77	4.31	+1.0	7	.....	sw.	.....	.....	.....	7	8	15	.....	.0	.0
Apalachicola	35	11	.....	29.92	29.96	.....	68.6	.....	84	1	75	45	14	62	18	63	.....	.....	4.85	+2.0	8	.....	s.	.....	.....	.....	12	11	7	.....	.0	.0
Pensacola	56	149	185	29.90	29.96	−.06	67.4	+.7	81	11	73	47	9	62	17	62	60	80	5.48	+1.4	10	8,319	s.	48	sw.	2	15	11	4	4.1	.0	.0
Anniston	741	9	.....	.....	.....	.....	63.6	+3.2	87	26	75	35	14	53	33	.....	.....	.....	4.40	.0	11	.....	nw.	.....	.....	.....	10	5	15	.....	.0	.0
Birmingham	700	11	48	29.17	29.93	−.09	63.2	−.1	85	25	73	38	14	54	31	56	52	73	4.78	.0	14	4,902	sw.	30	nw.	5	8	8	14	6.0	.0	.0
Mobile	57	125	161	29.88	29.94	−.08	67.6	+1.3	83	11	75	46	14	60	23	61	58	79	5.59	+1.0	10	6,507	s.	37	s.	6	13	8	9	5.1	.0	.0
Montgomery	218	92	105	29.70	29.95	−.08	66.0	+.7	86	26	75	41	14	57	27	58	53	71	3.85	−.4	9	5,224	sw.	21	sw.	27	9	6	15	6.1	.0	.0
Meridian	375	67	92	29.54	29.94	−.08	64.9	+.9	87	25	75	38	14	55	34	57	53	74	5.86	+1.1	10	4,393	sw.	24	sw.	11	9	8	13	5.5	.0	.0
Vicksburg	247	65	73	29.68	29.94	−.06	64.9	−.7	83	24	73	46	13	57	28	58	54	74	2.97	−2.2	8	5,467	nw.	25	nw.	29	9	5	16	6.1	.0	.0
New Orleans	53	76	84	29.89	29.94	−.06	70.3	+1.5	85	25	78	52	8	63	20	63	60	76	8.35	+3.1	11	4,970	se.	18	nw.	6	6	11	13	6.4	.0	.0
West Gulf States							**66.7**	**+0.3**										**72**	**3.21**	**−0.6**										**6.1**		
Shreveport	249	92	227	29.66	29.93	−.04	65.9	+.1	86	1	75	44	8	57	29	59	54	71	5.16	+.5	10	8,188	se.	44	w.	5	9	9	12	6.0	.0	.0
Bentonville	1,303	11	44	28.54	29.90	−.06	55.1	−1.8	79	24	64	31	8	46	31	.....	.....	.....	2.87	−2.0	12	5,366	ne.	20	nw.	11	3	8	19	.....	T	.0
Fort Smith	457	79	94	29.43	29.91	−.05	59.8	−2.0	82	24	69	39	13	51	31	52	47	68	3.27	−.7	6	6,437	e.	28	w.	11	3	11	16	7.1	.0	.0
Little Rock	357	94	102	29.56	29.94	−.04	60.2	−1.9	82	28	68	41	8	52	29	53	47	68	3.47	−1.7	11	6,256	se.	35	nw.	6	7	5	18	6.9	.0	.0
Austin	605	136	148	29.26	29.89	.....	69.2	+1.4	91	6	79	41	13	60	36	60	53	66	1.79	−2.6	8	6,672	se.	26	n.	12	7	8	15	6.8	.0	.0
Brownsville	57	88	96	29.78	29.84	.....	75.5	+1.8	92	29	83	54	13	68	28	69	67	83	2.04	+.6	9	8,774	se.	38	se.	1	3	18	9	6.1	.0	.0
Corpus Christi	20	11	78	29.85	29.87	−.08	73.3	+2.5	87	6	78	54	13	68	18	68	65	79	1.16	−.6	4	9,004	se.	30	n.	3	7	11	12	6.2	.0	.0
Dallas	512	220	227	29.35	29.89	.....	63.4	.....	91	1	73	43	7	54	39	56	50	67	1.91	−2.4	8	9,471	se.	35	ne.	19	6	6	18	7.0	.0	.0
Fort Worth	679	92	110	29.20	29.91	−.03	64.6	−.4	92	1	75	39	13	54	40	.....	.....	.....	3.06	−1.0	7	8,224	n.	32	n.	11	14	7	9	4.1	.0	.0
Galveston	54	106	114	29.86	29.92	−.05	70.2	+1.5	82	29	75	54	8	66	17	65	62	80	4.17	+1.1	8	8,681	se.	27	n.	7	9	14	7	5.0	.0	.0
Houston	138	292	314	29.77	29.92	.....	70.0	+.7	86	1	78	49	8	62	26	.....	.....	.....	3.63	.0	10	9,085	se.	41	se.	29	5	12	13	6.5	.0	.0
Palestine	510	64	72	29.39	29.92	−.04	66.0	.0	87	5	75	42	8	57	30	59	55	73	5.63	+1.2	9	5,978	s.	23	n.	6	6	10	14	6.1	.0	.0
Port Arthur	34	58	66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
San Antonio	693	242	301	29.15	29.86	−.07	70.4	+1.3	91	6	80	48	13	61	30	62	57	70	3.52	+.3	10	8,849	e.	44	nw.	29	3	15	12	6.5	.0	.0

Footnotes at end of table.

TABLE I.—*Climatological data for Weather Bureau stations, April 1935*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Ohio Valley and Tennessee							**53.3**	**−1.5**										**69**	**3.01**	**−0.7**										**6.8**		
Chattanooga	762	71	214	29.12	29.92	−0.11	61.8	+1.5	87	26	71	40	16	52	31	54	49	67	5.84	+1.0	13	5,657	w.	32	w.	15	9	8	13	5.9	0.0	0.0
Knoxville	995	66	84	28.87	29.92	−.11	58.8	+.8	87	26	67	35	17	50	29	52	48	72	5.95	+1.8	13	4,284	w.	26	w.	15	9	10	11	6.2	.0	.0
Memphis	399	78	86	29.50	29.93	−.07	59.8	−2.0	85	26	67	41	8	52	25	53	48	69	2.82	−2.0	8	5,167	nw.	32	n.	5	7	9	14	6.4	.0	.0
Nashville	546	168	191	29.36	29.95	−.06	58.0	−1.0	85	26	67	36	16	49	31	52	47	72	4.51	+.4	11	6,493	nw.	31	nw.	7	7	10	13	6.4	.0	.0
Lexington	989	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Louisville	525	188	234	29.37	29.96	−.05	54.2	−2.2	87	26	63	30	16	46	30	47	42	68	2.98	−.9	11	7,042	n.	35	w.	15	7	8	15	6.7	T	.0
Evansville	431	76	116	29.47	29.94	−.06	55.1	−1.6	85	26	63	32	16	47	26	48	42	68	2.90	−1.0	12	6,384	n.	29	nw.	15	4	9	17	7.0	.0	.0
Indianapolis	822	194	230	29.07	29.96	−.04	49.0	−3.1	84	26	58	25	15	40	34	42	36	64	1.54	−2.1	9	8,368	e.	39	w.	15	3	9	18	7.7	.2	.0
Terre Haute	575	96	129	29.31	29.94	.....	51.8	.....	87	26	61	30	16	43	30	44	38	67	2.13	−1.5	11	7,287	n.	36	nw.	15	4	11	15	7.1	T	.0
Cincinnati	627	11	51	29.27	29.95	−.06	50.5	−1.9	84	26	59	25	16	42	32	44	39	71	2.26	−.9	12	5,653	ne.	28	w.	15	5	7	18	7.5	.4	.0
Columbus	822	90	210	29.07	29.95	−.07	49.1	−2.1	84	26	58	22	16	41	35	43	37	68	1.88	−1.0	9	6,432	ne.	43	sw.	27	6	6	18	7.1	.5	.0
Dayton	900	58	153	28.97	29.94	.....	49.4	−2.2	82	26	58	24	15	41	32	.....	.....	.....	2.26	−.9	9	6,118	ne.	33	w.	15	2	10	18	.....	.2	.0
Elkins	1,947	59	78	27.90	29.97	−.06	46.0	−2.8	82	27	56	17	16	36	47	41	36	73	3.04	−.6	18	4,874	w.	34	nw.	30	3	10	17	7.4	2.8	.0
Parkersburg	637	77	84	29.31	29.97	−.06	51.4	−2.0	84	26	60	23	16	42	40	45	39	69	2.17	−1.0	13	4,912	nw.	30	w.	15	7	9	14	6.4	1.0	.0
Pittsburgh	842	353	410	29.04	29.95	−.07	50.0	−1.2	86	27	59	23	16	41	37	43	38	71	1.91	−1.0	12	7,605	w.	38	w.	15	4	12	14	6.8	1.0	.0
Lower Lake Region							**44.0**	**−1.4**										**72**	**2.14**	**−0.4**										**6.6**		
Buffalo	768	243	280	29.11	29.96	−.05	41.0	−1.8	71	27	47	22	16	35	25	37	33	77	.88	−1.7	13	10,046	sw.	50	sw.	15	8	6	16	6.5	1.1	.0
Canton	448	10	61	29.43	29.91	.....	42.0	−.5	80	27	51	20	6	33	34	.....	.....	.....	4.04	+1.9	15	6,280	e.	27	w.	30	3	11	16	7.2	9.7	.0
Ithaca	836	77	100	29.02	29.94	.....	43.4	−1.6	86	27	52	24	6	34	40	39	34	72	3.59	+1.1	15	6,465	nw.	27	w.	30	4	12	14	7.2	11.7	.0
Oswego	335	71	85	29.57	29.94	−.07	42.6	−1.0	84	27	49	26	7	36	35	38	32	71	2.16	−.2	13	7,069	w.	27	w.	30	5	8	17	6.9	.9	.0
Rochester	523	86	102	29.38	29.96	−.05	44.4	−.5	82	27	52	25	16	37	31	39	33	68	1.48	−.9	14	6,417	w.	31	sw.	30	9	9	12	5.8	.7	.0
Syracuse	596	65	79	.....	29.94	−.07	44.4	.0	87	27	52	26	7	37	34	.....	.....	.....	3.51	+1.0	13	5,711	nw.	23	sw.	30	8	6	16	.....	9.5	.0
Erie	714	130	166	29.18	29.96	−.06	43.8	−1.3	82	27	50	23	16	37	29	39	34	75	1.17	−1.6	10	8,826	nw.	40	w.	15	12	7	11	5.4	1.1	.0
Cleveland	762	267	337	29.13	29.96	−.06	44.6	−1.6	79	26	51	22	15	38	35	39	34	70	1.34	−1.1	10	9,551	w.	43	n.	6	8	6	16	6.6	3.6	.0
Sandusky	629	5	67	29.28	29.97	−.05	45.4	−1.8	78	26	52	23	15	39	34	.....	.....	.....	1.51	−1.0	8	7,116	ne.	34	nw.	15	7	6	17	6.6	.3	.0
Toledo	628	79	87	29.30	29.99	−.02	45.4	−2.2	81	26	53	22	16	38	35	40	34	70	1.46	−1.2	9	7,374	e.	31	e.	7	8	8	14	6.5	.1	.0
Fort Wayne	857	69	84	29.04	29.98	.....	46.2	−3.1	81	26	54	22	15	38	35	41	35	71	2.15	−.9	8	6,910	ne.	32	nw.	15	7	7	16	7.0	.8	.0
Detroit[1]	626	5	78	29.29	29.99	−.03	44.4	−1.8	77	26	53	21	16	36	36	39	33	70	2.39	−.1	8	7,160	ne.	37	nw.	15	4	9	17	7.1	.2	.0
Upper Lake Region							**40.5**	**−1.0**										**71**	**1.53**	**−0.9**										**6.3**		
Alpena	609	13	89	29.35	30.02	.00	40.2	+1.6	71	26	48	24	15	33	30	35	30	69	.63	−1.6	5	7,632	nw.	29	nw.	15	12	9	9	4.9	.6	.0
Escanaba	612	54	60	29.38	30.07	+.05	37.4	−.5	60	24	45	16	15	30	24	33	28	73	1.11	−1.1	8	7,679	n.	35	n.	12	8	7	15	6.0	3.5	.0
Grand Rapids	707	70	244	29.22	30.00	−.02	44.9	−2.1	82	26	54	20	15	36	31	38	32	65	1.35	−1.4	10	8,398	ne.	37	e.	7	5	10	15	6.8	2.2	.0
Lansing	878	6	88	29.03	29.99	.....	43.6	−2.0	80	26	53	20	15	34	38	39	35	76	1.60	−1.0	9	6,957	e.	32	w.	15	5	11	14	6.8	.8	.0
Ludington	637	5	54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Marquette	734	77	111	29.25	30.07	+.05	36.5	−1.3	72	26	42	15	15	31	36	33	29	76	1.87	−.6	8	6,578	nw.	33	nw.	15	7	11	12	6.2	7.3	T
Sault Sainte Marie	614	11	52	29.35	30.06	+.03	39.6	+2.2	67	25	49	18	16	30	33	33	26	64	.76	−1.4	8	5,696	nw.	35	nw.	15	10	11	9	5.3	2.5	.0
Chicago	673	7	131	29.28	30.00	.00	44.0	−2.9	84	26	49	26	15	39	29	39	34	73	1.77	−1.0	11	8,284	ne.	32	nw.	14	4	10	16	6.9	.6	.0
Green Bay	617	109	141	29.35	30.02	+.01	41.4	−1.8	78	26	49	16	15	34	37	36	31	69	1.70	−1.0	10	8,495	ne.	34	nw.	15	5	8	17	6.9	7.3	.0
Milwaukee	681	97	221	29.27	30.02	+.03	41.5	−2.3	69	26	47	20	15	36	31	37	32	72	3.05	+.4	12	9,360	ne.	38	n.	12	4	9	17	7.0	.4	.0
Duluth	1,133	5	47	28.82	30.07	+.06	35.7	−1.3	65	14	43	11	15	28	52	32	28	77	1.45	−.6	7	9,577	ne.	51	nw.	14	8	5	17	6.3	.5	.0
North Dakota							**39.3**	**−1.6**										**74**	**2.04**	**+0.4**										**6.4**		
Moorhead, Minn	940	50	58	29.01	30.05	+.06	39.3	−1.3	67	22	47	15	15	32	30	36	32	78	2.46	+.3	12	6,877	se.	27	nw.	14	6	4	20	7.3	10.8	.0
Bismarck	1,674	8	57	28.21	30.03	+.06	40.2	−1.9	72	21	49	13	2	31	36	35	29	71	3.03	+1.5	16	8,190	se.	35	w.	13	6	11	13	6.7	5.4	.0
Devils Lake	1,478	11	44	28.46	30.07	+.08	37.6	−1.2	67	22	46	10	2	29	32	33	30	79	1.67	+.2	9	7,321	se.	32	nw.	14	6	6	18	7.1	1.1	.0
Grand Forks	833	12	67	.....	.....	.....	38.4	.....	69	22	47	15	15	30	32	35	.....	.....	2.00	.....	7	.....	se.	35	nw.	15	5	16	9	.....	3.8	.0
Williston	1,878	41	48	28.00	30.01	+.05	40.0	−2.0	76	21	50	8	2	30	36	34	27	67	1.02	−.2	6	7,552	se.	35	nw.	13	11	12	7	4.7	2.4	.0
Upper Mississippi Valley							**48.2**	**−2.1**										**70**	**2.41**	**−0.6**										**6.9**		
Minneapolis	918	102	208	29.03	30.02	.....	44.0	−2.4	76	25	52	18	15	36	41	38	32	66	2.32	+.1	10	8,874	se.	40	nw.	15	6	6	18	6.6	6.9	.0
La Crosse	714	11	48	29.22	30.00	+.02	46.0	−1.2	78	25	55	21	15	37	41	40	34	68	2.40	.0	12	4,963	nw.	23	nw.	15	6	8	16	6.6	.1	.0
Madison	974	70	78	28.94	30.00	+.01	43.4	−2.0	80	26	51	21	15	36	33	39	35	76	1.82	−1.0	11	7,570	se.	31	nw.	14	5	7	18	7.1	.1	.0
Charles City	1,015	10	51	28.91	30.00	+.02	45.0	−1.4	73	25	54	21	15	36	43	39	34	72	2.91	+.4	12	6,396	se.	27	nw.	15	6	10	14	6.3	T	.0
Davenport	606	66	161	29.32	29.99	+.01	48.0	−1.8	78	25	56	26	15	39	34	42	36	68	2.24	−.4	12	8,490	ne.	38	nw.	15	3	11	16	7.3	.1	.0
Des Moines	861	5	99	29.06	29.97	.00	48.3	−1.9	77	25	57	26	16	40	41	42	36	66	.74	−2.2	5	8,264	se.	39	nw.	14	4	8	18	7.2	.2	.0
Dubuque	700	60	79	29.24	29.99	+.01	47.0	−1.6	78	26	55	24	15	39	36	40	34	65	1.57	−1.3	10	5,832	e.	30	nw.	14	3	9	18	7.2	T	.0
Keokuk	614	64	78	29.30	29.98	.00	49.4	−2.9	79	25	58	28	16	41	33	43	38	68	2.48	−.5	9	6,453	n.	30	n.	15	3	9	18	7.5	2.5	.0
Cairo	358	87	93	29.55	29.93	−.06	56.4	−1.7	85	26	64	37	16	49	23	49	43	68	3.69	.0	12	6,899	n.	26	nw.	15	5	9	16	6.7	.0	.0
Peoria	609	11	45	29.32	29.99	.00	48.4	−2.5	84	26	57	28	15	40	32	43	38	71	2.91	−.5	9	6,328	ne.	28	w.	15	5	13	12	6.5	3.0	.0
Springfield, Ill	636	5	191	29.28	29.96	−.02	50.2	−2.5	84	26	58	30	16	42	28	45	40	73	3.39	−.1	11	8,666	se.	38	nw.	15	4	9	17	7.5	1.6	.0
St. Louis	568	265	303	29.33	29.94	−.04	52.4	−3.4	84	26	60	32	16	45	30	46	42	73	2.50	−1.3	13	8,527	ne.	35	nw.	15	9	7	14	6.3	T	.0
Missouri Valley							**49.4**	**−2.4**										**68**	**2.86**	**0.0**										**6.6**		
Columbia, Mo	784	6	84	29.10	29.94	−.04	52.1	−2.8	83	25	60	30	16	44	40	.....	.....	.....	2.66	−1.1	12	6,697	n.	30	nw.	14	6	9	15	6.7	T	.0
Kansas City[1]	750	32	45	29.13	29.94	−.02	52.2	−2.6	82	14	62	31	3	43	43	45	39	67	2.30	−.8	11	8,108	n.	43	nw.	14	4	10	16	6.6	1.0	.0
St. Joseph	967	11	49	28.90	29.94	.....	51.0	.....	81	14	60	29	15	42	46	44	37	65	3.10	+.1	10	7,230	se.	35	nw.	14	9	7	14	5.9	T	.0
Springfield, Mo	1,324	98	104	28.52	29.93	−.04	53.2	−2.8	79	24	61	32	8	45	30	47	41	69	1.86	−2.0	11	7,964	se.	28	nw.	14	7	6	17	6.5	T	.0
Iola	984	11	50	28.87	29.92	−.03	54.3	−1.9	79	22	65	31	15	44	46	.....	.....	.....	2.97	−.5	10	.....	ne.	.....	.....	.....	4	11	15	.....	.0	.0
Topeka	987	65	87	.....	.....	.....	52.4	−2.3	85	14	63	30	15	42	48	.....	.....	.....	2.09	−.7	8	7,961	ne.	32	nw.	14	6	11	13	6.3	T	.0
Lincoln	1,189	11	81	28.66	29.94	.00	49.6	−1.9	81	22	59	26	15	40	47	42	35	65	1.33	−1.2	8	8,508	n.	40	nw.	14	7	7	16	6.9	T	.0
Omaha	1,105	170	200	28.77	29.96	+.01	49.4	−1.8	82	22	59	25	4	40	40	42	34	61	.80	−1.7	9	9,331	n.	44	nw.	14	6	7	17	6.8	1.1	.0
Valentine	2,598	47	54	27.23	29.98	+.04	41.0	−4.7	78	22	50	16	2	32	38	36	30	71	4.45	+2.6	12	9,021	n.	30	n.	14	8	4	18	6.7	12.2	.0
Sioux City	1,138	64	106	28.73	29.96	+.01	47.0	−.8	83	22	56	24	15	38	36	41	35	69	4.31	+1.6	13	8,002	se.	45	nw.	14	7	3	20	7.4	.2	.0
Huron	1,306	60	74	28.58	30.00	+.04	42.4	−2.7	76	22	51	20	2	34	37	38	34	78	5.64	+3.4	13	8,006	se.	31	nw.	14	8	7	15	6.2	26.9	.0
Northern Slope							**39.3**	**−3.9**										**63**	**2.07**	**+0.5**										**6.2**		
Billings	3,570	17	31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Havre	2,505	11	67	27.33	30.01	+.08	38.2	−5.5	75	20	50	0	2	26	45	32	25	65	1.15	+.2	12	6,785	sw.	33	nw.	13	7	13	10	5.7	4.4	.0
Helena	4,124	85	111	25.73	29.99	+.02	36.9	−6.6	69	20	48	−4	2	26	46	30	22	58	.70	−.4	10	6,162	sw.	31	s.	15	5	7	18	7.1	4.2	.0
Kalispell	2,973	48	56	26.89	29.98	+.02	38.2	−5.4	64	25	49	7	2	28	35	33	26	67	1.81	+1.0	13	4,946	nw.	27	n.	29	7	12	11	6.0	5.5	.0
Miles City	2,371	48	55	27.44	30.02	+.06	42.2	−2.5	82	21	53	7	2	31	43	35	26	58	.90	−.2	8	6,057	nw.	26	n.	14	10	12	8	5.2	1.7	.0
Rapid City	3,259	50	58	26.56	30.03	+.08	40.6	−3.7	78	21	50	13	2	31	36	34	27	65	2.78	+.8	12	8,062	n.	32	n.	25	7	12	11	6.2	15.2	.0
Cheyenne	6,094	50	71	23.90	29.93	+.02	38.0	−2.9	69	13	49	10	29	26	38	31	24	65	2.95	+1.0	13	9,358	nw.	37	nw.	4	4	12	14	6.9	27.2	T
Lander	5,372	60	68	24.54	29.93	−.01	40.2	−2.2	71	15	52	10	1	28	41	32	23	57	2.91	+.8	9	4,613	sw.	37	sw.	15	8	9	13	5.9	18.9	.0
Sheridan	3,790	10	47	26.03	29.98	.....	39.0	.....	79	21	52	8	2	26	54	32	25	62	1.34	−.6	13	5,173	nw.	30	nw.	27	8	11	11	5.8	11.0	.0
Yellowstone Park	6,241	11	48	.....	29.96	.00	33.4	−3.6	61	20	44	−5	1	23	37	.....	.....	68	2.07	+.6	20	6,525	sw.	32	sw.	15	5	8	17	.....	23.7	.0
North Platte	2,821	11	51	26.98	29.92	.00	45.9	−2.7	83	22	57	21	2	35	40	38	30	64	4.08	+2.0	12	7,436	n.	32	se.	9	3	15	12	6.9	.6	.0

TABLE I.—*Climatological data for Weather Bureau stations, April 1935*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Middle Slope							51.6	−1.8										54	1.48	−0.8										6.3		
Denver	5,292	106	113	24.61	29.87	−0.03	45.5	−1.6	78	13	57	18	2	34	38	36	25	51	4.07	+2.0	9	6,349	s.	31	nw.	6	5	13	12	6.6	23.3	0.0
Pueblo	4,685	80	86	25.17	29.84	−.04	50.8	+.7	81	13	64	26	1	38	50	38	23	40	.42	−.9	4	6,737	e.	34	nw.	14	10	10	10	5.4	T	.0
Concordia	1,392	50	58	28.47	29.95	+.02	51.2	−2.3	84	14	62	27	15	40	50	42	34	59	.72	−1.6	8	8,108	n.	31	n.	11	9	8	13	6.0	T	.0
Dodge City	2,509	10	86	27.32	29.92	+.02	51.8	−1.8	84	14	65	26	7	39	43	41	30	50	.03	−1.9	1	11,655	s.	38	nw.	10	8	10	12	5.8	.0	.0
Wichita	1,358	85	93	28.48	29.92	−.01	52.8	−3.6	83	14	62	33	8	44	41	45	37	60	1.86	−1.0	8	9,628	se.	30	se.	9	8	6	16	6.5	.0	.0
Oklahoma City	1,214	10	47	28.63	29.91	−.01	57.8	−2.0	86	14	68	36	8	48	35	50	44	66	1.81	−1.5	5	8,467	n.	27	n.	14	6	6	18	7.3	.0	.0
Southern Slope							64.3	+1.4										43	0.66	−1.2										5.1		
Abilene	1,738	10	52	28.08	29.87	−.03	65.8	+1.4	96	14	78	39	13	53	41	52	40	50	1.55	−1.2	5	8,377	s.	28	s.	23	9	11	10	5.4	.0	.0
Amarillo	3,676	10	49	26.16	29.86	−.01	56.8	+1.0	90	14	70	31	12	44	41	42	27	39	.05	−1.8	2	7,958	se.	27	n.	10	7	11	12	5.7	.0	.0
Big Spring	2,537	5	62	27.27	29.86	------	65.0	------	95	14	78	41	13	52	39	50	36	43	1.20	------	3	------	ne.	----	----	----	12	10	8	4.7	.0	.0
Del Rio	944	64	71	28.83	29.80	−.09	73.3	+2.7	93	24	84	51	13	63	32	61	51	54	.67	−1.1	3	8,037	se.	34	w.	4	9	12	9	5.2	.0	.0
Roswell	3,566	75	85	26.26	29.83	−.02	61.2	+.6	90	14	75	39	20	47	41	45	24	31	.39	−.5	3	7,466	s.	34	nw.	24	13	9	8	4.6	.0	.0
Southern Plateau							58.7	+1.4										40	0.37	0.0										3.9		
El Paso	3,778	152	175	26.09	29.82	−.01	65.3	+1.9	88	16	78	44	11	53	30	46	26	26	.02	−.2	2	8,582	w.	43	w.	16	20	8	2	2.5	.0	.0
Albuquerque	4,972	5	39	24.95	29.79	------	54.1	------	82	14	69	29	7	40	39	39	27	42	.48	−.1	3	7,978	w.	40	w.	9	9	14	7	5.2	.0	.0
Santa Fe	7,013	38	53	23.17	29.84	.00	46.8	+.1	71	14	58	26	10	36	30	37	26	47	1.02	.0	5	5,398	se.	24	s.	9	8	15	7	5.4	1.0	.0
Flagstaff	6,907	10	59	23.26	29.81	−.03	43.3	+1.1	68	14	57	22	9	30	39	35	----	58	1.45	------	3	7,679	sw.	33	sw.	9	4	19	7	----	T	T.
Phoenix	1,108	10	107	28.69	29.83	−.04	69.4	+2.4	93	14	83	41	10	56	36	51	33	31	.09	−.3	1	4,750	e.	25	nw.	17	18	5	7	3.5	.0	.0
Yuma	141	9	54	29.70	29.85	−.04	70.7	+1.2	98	14	86	43	10	56	42	54	38	36	.01	−.1	1	5,607	w.	29	nw.	9	20	6	4	2.8	.0	.0
Independence	3,957	5	26	29.87	29.88	−.02	56.6	+1.5	82	23	71	28	9	42	41	42	----	----	.60	+.5	3	------	nw.	----	------	----	14	12	4	----	.0	.0
Middle Plateau							48.4	0.0										50	1.92	+0.9										6.2		
Reno	4,527	61	76	25.39	29.91	−.06	47.7	+.4	74	19	59	30	8	36	39	39	29	53	1.64	+1.2	7	6,041	w.	35	w.	29	5	14	11	6.0	T	.0
Tonopah	6,090	12	20	------	------	------	46.8	------	72	20	58	18	9	36	33	36	22	42	.46	------	2	------	w.	----	----	----	----	----	----	----	----	----
Winnemucca	4,344	18	56	25.53	29.92	−.04	46.0	−.7	74	19	59	20	24	33	41	38	29	59	3.34	+2.5	11	6,502	sw.	31	w.	21	9	5	16	6.2	6.9	.0
Modena	5,473	10	46	24.50	29.82	−.06	46.8	+.8	74	14	61	23	6	32	42	36	24	48	.47	−.4	6	8,647	sw.	49	sw.	15	6	12	12	6.2	.2	.0
Salt Lake City	4,357	86	210	25.51	29.86	−.06	49.8	+.2	76	20	60	32	17	40	31	40	29	49	2.89	+.8	12	6,114	s.	44	w.	15	7	5	18	6.7	2.1	.0
Grand Junction	4,602	60	68	25.25	29.82	−.06	51.9	−.5	79	15	64	31	11	40	33	40	27	46	1.25	+.4	10	5,511	se.	31	s.	15	8	11	11	5.9	T	.0
Northern Plateau							47.0	−2.2										54	1.84	+0.7										5.5		
Baker	3,471	48	53	26.37	29.97	−.03	42.9	−2.3	67	19	54	18	2	32	35	36	29	62	2.08	+1.0	14	4,869	se.	24	sw.	20	9	9	12	5.7	5.2	.0
Boise	2,739	79	87	27.07	29.94	−.04	48.8	−1.6	73	19	59	31	28	38	31	41	33	57	2.88	+1.7	12	4,966	se.	24	nw.	9	7	7	16	6.3	T	.0
Pocatello	4,477	60	68	25.36	29.88	−.06	45.7	−.3	71	20	56	26	1	36	35	37	28	56	2.94	+1.5	13	7,045	sw.	34	s.	15	10	7	13	5.8	4.2	.0
Spokane	1,929	101	110	27.91	29.98	−.01	45.2	−3.2	69	12	55	21	2	35	35	37	27	55	.92	−.2	9	5,149	s.	21	s.	12	11	7	12	5.3	T	.0
Walla Walla	991	57	65	28.89	29.96	−.05	49.5	−3.6	71	19	59	24	2	40	31	42	32	55	2.13	+.6	11	4,429	s.	21	se.	12	10	9	11	5.3	T	.0
Yakima	1,076	58	67	28.82	29.98	------	50.0	−2.5	78	25	62	22	2	38	34	39	24	41	.06	−.4	3	4,932	nw.	23	nw.	30	15	3	12	4.7	.2	.0
North Pacific Coast Region							50.1	+0.9										70	2.26	−0.8										5.7		
North Head	211	11	56	29.78	30.01	−.04	48.2	+.7	72	27	53	37	2	43	22	44	40	77	1.85	−2.3	11	8,377	n.	52	s.	22	11	7	12	5.3	.0	.0
Seattle	125	90	321	29.86	29.99	−.04	50.7	+1.3	76	28	59	34	2	42	30	44	36	63	1.55	−.8	9	7,074	n.	34	sw.	20	11	12	7	4.5	.0	.0
Tatoosh Island	86	10	54	29.90	30.00	.00	47.4	+1.3	64	28	52	37	1	43	15	44	40	80	2.76	−2.9	10	9,353	e.	38	e.	1	13	5	12	4.9	.0	.0
Medford	1,329	29	58	28.55	29.96	------	51.8	------	84	26	64	31	17	40	45	45	37	65	2.05	+.8	13	4,245	nw.	27	se.	12	6	9	15	6.9	.0	.0
Portland, Oreg	153	68	106	29.83	29.99	−.07	51.7	−.1	75	11	60	36	2	43	31	45	38	64	2.48	−.4	12	5,180	nw.	21	e.	28	7	10	13	6.1	.0	.0
Roseburg	510	45	76	29.94	29.99	−.08	52.4	+1.4	80	27	63	35	10	41	39	46	41	72	2.85	+.6	16	3,466	n.	20	w.	20	6	11	13	6.4	.0	.0
Middle Pacific Coast Region							56.2	+1.8										73	4.85	+2.7										6.6		
Eureka	62	73	89	29.94	30.01	−.10	51.2	+1.3	65	26	57	38	8	45	19	48	46	86	5.29	+2.0	15	5,097	n.	25	n.	24	4	10	16	7.1	.0	.0
Redding	722	20	34	------	------	------	57.2	------	87	27	65	33	9	49	31	49	41	62	7.98	------	13	5,423	nw.	29	se.	15	7	2	21	7.4	.0	.0
Sacramento	69	92	115	29.88	29.96	−.05	58.6	+.5	80	25	67	40	9	50	29	52	46	70	5.81	+4.3	11	5,237	sw.	25	nw.	24	9	13	8	5.3	.0	.0
San Francisco	155	208	243	29.80	29.97	−.08	58.7	+3.7	81	26	65	46	9	52	23	52	48	73	3.45	+1.8	12	5,230	w.	29	nw.	8	6	7	17	6.4	.0	.0
South Pacific Coast Region							60.4	+1.1										72	2.33	+1.4										6.0		
Fresno	327	97	105	29.61	29.97	−.02	60.6	+.4	89	26	72	41	9	50	33	53	47	67	2.77	+1.8	8	4,443	nw.	24	sw.	15	7	10	13	5.8	.0	.0
Los Angeles	338	159	191	29.61	29.97	−.02	60.7	+1.3	83	25	68	46	9	53	31	54	49	72	3.19	+2.2	5	4,380	sw.	22	sw.	8	9	9	12	5.6	.0	.0
San Diego	87	62	70	29.88	29.97	−.02	60.0	+1.5	74	14	66	44	10	54	21	55	52	78	1.02	+.2	7	5,157	nw.	25	s.	8	5	11	14	6.7	.0	.0
West Indies																																
San Juan, P. R.	82	9	54	29.89	29.98	------	76.2	−.4	85	14	82	66	4	71	15	----	----	----	.42	−3.9	5	7,900	e.	27	e.	9	6	23	1	5.2	.0	.0
Panama Canal																																
Balboa Heights	118	6	97	------	[2]29.82	------	81.4	−.2	93	24	90	68	7	73	20	----	----	[2]77	2.40	−.6	6	5,872	nw.	25	n.	13	1	26	3	5.7	.0	.0
Cristobal	36	6	97	------	[2]29.85	------	81.6	−.2	88	23	86	72	7	78	13	75	73	[2]76	1.87	−2.3	12	8,546	n.	27	nw.	14	5	14	11	5.7	.0	.0
Alaska																																
Fairbanks	454	11	87	------	------	------	----	------	----	----	----	----	----	----	----	----	----	----	----	------	----	----	----	----	----	----	----	----	----	----	----	----
Juneau	80	96	116	[2]29.90	[2]29.99	------	39.6	------	56	30	46	26	1	34	25	35	28	65	4.96	------	16	5,446	s.	25	e.	18	4	7	19	7.4	.4	.0
Hawaiian Islands																																
Honolulu	38	86	100	[2]30.02	[2]30.06	------	72.5	−.5	80	29	77	65	14	68	13	64	60	68	.25	−1.9	7	8,259	e.	28	ne.	10	17	3	10	4.3	.0	.0

[1] Observations taken at airport.
[2] Observations taken bihourly.
[3] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, April 1935*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min. ÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48												
Halifax, Nova Scotia	88												
Yarmouth, Nova Scotia	65												
Charlottetown, Prince Edward Island	38												
Chatham, New Brunswick	28												
Father Point, Quebec	20												
Quebec, Quebec	296	29.59	29.92	−0.07	39.2	+4.1	45.7	32.6	72	13	3.11	+1.02	3.3
Doucet, Quebec	1,236				31.6		44.3	18.9	64	−20	1.39		5.3
Montreal, Quebec	187												
Ottawa, Ontario	236												
Kingston, Ontario	285	29.61	29.93	−.09	42.0	+2.0	49.5	34.5	67	22	2.09	+.30	1.5
Toronto, Ontario	379	29.55	29.97	−.05	43.7	+2.9	51.0	36.4	68	25	.95	−1.42	2.2
Cochrane, Ontario	930				31.5		43.3	19.6	68	−1	1.45		4.1
White River, Ontario	1,244												
London, Ontario	808				40.6		49.4	31.9	70	18	1.95		.5
Southampton, Ontario	656	29.26	29.99	−.04	38.4	−.3	46.4	30.4	69	22	1.32	−.46	2.7
Parry Sound, Ontario	658	29.27	29.97	−.05	40.8	+3.2	50.2	31.5	64	19	1.90	−.01	4.6
Port Arthur, Ontario	644	29.36	30.09	+.06	34.6	+1.1	42.3	26.9	55	9	.95	−.77	4.9
Winnipeg, Manitoba	760	29.25	30.10	+.08	36.2	+.3	44.0	28.4	66	5	1.18	+.13	1.8
Minnedosa, Manitoba	1,690	28.23	30.09	+.08	33.8	−2.2	43.3	24.4	66	0	.97	−.09	3.3
Le Pas, Manitoba	860		30.11		30.8		42.8	18.9	64	−12	.77		.6
Qu'Appelle, Saskatchewan	2,115												
Moose Jaw, Saskatchewan	1,759				37.7		48.4	27.1	78	1	.42		1.6
Swift Current, Saskatchewan	2,392	27.40	29.96	.00	36.4	−4.9	46.6	26.3	76	−6	1.53	+.60	1.3
Medicine Hat, Alberta	2,365	27.41	29.93	+.01	36.6	−7.9	46.4	26.7	70	2	2.30	+1.56	11.6
Calgary, Alberta	3,540	26.24	29.99	+.09	32.0	−7.6	42.2	21.9	62	1	1.62	+.98	16.2
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.52	30.14	+.16	31.6	−4.5	41.6	21.6	62	−6	1.73	+.90	14.8
Battleford, Saskatchewan	1,592	28.26	30.05	+.08	31.9	−5.3	43.3	20.6	72	−10	1.84	+1.37	7.6
Edmonton, Alberta	2,150												
Kamloops, British Columbia	1,262												
Victoria, British Columbia	230	29.74	29.99	−.02	48.6	+1.8	55.7	41.4	67	34	.38	−1.99	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20												
Prince Rupert, British Columbia	170												
Hamilton, Bermuda	151												
LATE REPORTS FOR MARCH 1935													
Quebec, Quebec	296	29.67	30.01	+0.05	22.9	+1.7	30.4	15.5	43	−8	2.78	−0.48	24.4
Ottawa, Ontario	236	29.75	30.03	+.02	26.6	+5.1	35.7	17.6	53	−10	1.75	−.97	7.0
Kingston, Ontario	285	29.70	30.02	+.01	31.5	+5.9	38.7	24.3	53	4	1.39	−1.25	2.0
London, Ontario	808				35.0		43.4	26.7	62	7	2.66		7.7
Winnipeg, Manitoba	760	29.06	29.92	−.17	18.0	+5.7	26.4	9.6	40	−13	2.84	+1.81	25.6
Qu'Appelle, Saskatchewan	2,115	27.52	29.84	−.20	16.1	+1.2	25.1	7.2	49	−19	1.31	+.54	13.1
Swift Current, Saskatchewan	2,392	27.26	29.89	−.13	19.8	−2.2	28.5	11.2	56	−32	1.41	+.60	14.1
Medicine Hat, Alberta	2,365	27.30	29.84	−.16	22.6	−4.9	30.5	14.8	58	−23	1.21	+.45	12.1
Calgary, Alberta	3,540	26.09	29.89	−.06	19.6	−6.6	29.1	10.1	59	−16	.94	+.22	9.4
Prince Albert, Saskatchewan	1,450	28.33	29.98	−.10	11.8	−.2	20.4	3.3	39	−20	.49	−.28	4.9
Battleford, Saskatchewan	1,592	28.13	29.95	−.11	12.0	−1.1	21.8	2.3	42	−31	.43	−.03	4.3
Victoria, British Columbia	230	29.67	29.93	−.04	42.1	+.2	47.2	37.1	57	31	2.94	−.18	.8
Hamilton, Bermuda	151	30.01	30.18	+.10	62.9	+.7	68.2	57.6	73	48	5.72	+.59	.0

SEVERE LOCAL STORMS, APRIL 1935

[Compiled by Mary O. Souder; authorities, U. S. Weather Bureau officials]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Georgetown, Tex.	2	3:30 p. m.	2,640		$35,000	Hail	$10,000 property damage; $25,000 loss to crops.
Turnerville, Tex.	2	do	5	0	800	Tornado	Property damaged.
Osceola, Tex.	3	5:30 a. m.	100	0		do	2 persons injured; house completely demolished; outbuildings unroofed.
Quemado Valley, Tex.	4	11:30 p. m.	[1] 2	1	500,000	do	139 persons injured; $50,000 property damage; $30,000 actual crop loss; $420,000 loss to crops soon to be harvested.
Antlers, Okla., and vicinity	5	1:30 p. m.	[1] 3			Heavy hail	Some damage to roofs and gardens; path 40 miles long.
Johnson County, Okla., northern portion.	5	do	[1] 10			do	No estimate of property damage, if any, obtainable; path 30 miles long.
Joiner, Ark.	5	2 p. m.	33	0	7,000	Tornado	6 persons injured; property damaged.
Arkadelphia, near, Ark.	5	3:30 p. m.	100	0	6,000	do	3 persons injured; damage to buildings $2,000; loss in timber $4,000; path 4 miles long.
Mendenhall, Miss.	5	7:30 p. m.	200	0	5,000	do	Property damaged; path 10 miles long.
Henderson, Tex., vicinity of	5	8 p. m.	880	1	10,000	Wind	Oil derricks destroyed; 1 person killed by falling derrick.
Corrigan, Tex.	6	3:30 p. m.	880	0	18,000	Tornado	7 persons injured; timber destroyed, $5,000; crop loss $1,000; property damage $12,000.
Cameron County, Tex.	6	4 p. m.	[1] 4		125,000	Hail	Loss to crops; roofs and windows damaged.
Polk County, Tex.	6	4:30–5 p. m.	440–800	0	10,000	Tornado	6 persons injured, 1 seriously; property damaged; path 15 miles long.
Shelbyville, Tex.	6	4:35 p. m.	200	0	1,500	do	9 persons injured; crop loss; property damaged.
Prichard, Ala (5 miles northwest of Mobile).	6	6:10 a. m.	167	0	3,500	Tornadic wind	15 loading sheds of the Stover Lumber Co., near railroad tracks lifted and dropped with slight damage; some flying timbers hit the dust collector on the power house, knocked down the boiler stacks and damaged part of the roof; loud roaring noise during the passage of this disturbance.
Lake Providence, La., vicinity of.	6	6:30 p. m.	880	9	75,000	Tornado	Numerous buildings destroyed; boathouse at logging camp overturned and 9 persons drowned.
Sicily Island, near, La.	6	do	17–33	0	15,000	do	Houses damaged or destroyed; path 3 miles long.
Doloroso, Miss., 6 miles southwest.	6	7:30 p. m.	100	3	10,000	do	Path 12 miles long, no details.
Ferriday, La.	6	9:30 p. m.	200	0	5,000	do	Buildings damaged; path 300 yards long.
Gloster, Miss., 1 mile southwest.	6	10:30 p. m.	500	8	250,000	do	Path 2 miles long; no details.
Liberty, Miss., 8 miles south.	6	11:30 p. m.	150	6	40,000	do	Path 8 miles long; no details.
Brentwood and Wookey, Ark.	6					Hail	Severe damage to gardens and crops.
Carlisle, Hazen, Lonoke, Ark., and vicinity.	6				30,000	do	Damage to roofs of buildings, automobile tops and gardens; path 10 miles wide in Lonoke and Prairie Counties.
Jacksonville and Palarm, Ark.	6					do	Considerable damage to growing crops and roofs of houses.
Thornburg, Ark., vicinity of.	6					do	Severe damage to gardens and considerable damage to roofs of buildings.
Plateau, Ala.	7	3:30 a. m.				Electrical and wind.	Small damage to filling station; trees blown down; path less than 100 feet wide and about a mile long.
Dade City, near, Fla.	7	12:20 a. m.			500	Tornadic wind	Damage covered area of 1 farm where the porch columns and kitchen flue were blown from the house; barn destroyed; brooder house and corn crib unroofed, the latter was moved about 10 feet and the debris scattered over a radius of 1,320 feet in three directions, north, northeast, and east.
Cherokee County, Ala.	7					Hail	Considerable damage to trees and windows.
Toledo, Ohio, vicinity of.	7–8					Wind, rain and snow.	Storm accompanied by dangerous gales along the lake shore; notably severe in the vicinity of Toledo.
Sacramento, Calif.	7–11			1		Flood	Rapid rise in the American River caused flooding in the lowland adjacent to north Sacramento; few families living in this area outside the American River Flood Control driven from home; highway traffic rerouted when floodgates on Del Pasa Boulevard leading to North Sacramento were closed on the evening of April 7–11.
Wellsville, N. Y., and vicinity.	8–9					Heavy snow	Automobile traffic greatly delayed; considerable damage to telephone and power lines, trees, and shrubs.
Dodge City, Kans.	9–11					Dust and high wind.	Most severe dust storm of all times from point of duration of dense dust and sustained high wind; dense dust from 9:15 a. m., on the 9th, to shortly after sunset of the 11th; semidarkness prevailed during most of daylight hours and at times was almost as dark as night; traffic on railroads and highways suspended; business practically at standstill.
Italy, Tex.	10	5:30 a. m.	[1] 2	0	3,000	Tornado	1 person injured; property damaged.
Havre, Mont., and vicinity.	13–14					Heavy snow and wind.	Blizzard conditions of thick, heavy snow accompanied by strong to gale-force northwest wind and rapidly falling temperature from 4 to 7 p. m., of the 13th; snow drifted considerably all night of 13–14, drifts in some places being 12 inches; some ranchers in Choteau and Blaine Counties sustained heavy losses of lambs and calves.
Des Moines, Iowa.	14	P. m.				Wind	Trees blown down; windows broken; maximum wind velocity of 39 miles an hour recorded.
Colorado, Denver, southern and eastern counties.	14–15					Dust and wind	Storm struck Denver at 2 p. m. of the 14th and blotted out the sun as it moved southward; sand drifts stopped trains and automobiles and grounded airplanes during the night of the 14th; wind on the 15th drifted dust to depths of from 2 to 5 feet along fences in east-central and southeastern counties and to depths of 9 feet in places between Bernalillo, N. Mex., and Durango, Colo.; visibility became so limited at times that motorists made little progress; artificial lights used during day; storm generated sufficient static electricity to render automobile ignition systems useless and scores of motorists were temporarily stranded, many resorted to the use of dragging chains and wires to ground the static accumulation to prevent short circuits.
Minnesota, most of the State.	14–15			3	2,500	Wind and dust	Considerable minor property damage over the entire State; 3 persons injured; 4 men in small boat, near Little Marais, blown out onto Lake Superior and 2 were drowned; light dust accompanied the storm on the 14th, being almost thick at times during the forenoon of the 15th; at Winona the sun was obscured part of the day.
Wisconsin.	14–15				40,00	Wind, sleet, and glaze.	Strong northwest winds and gales in practically the entire State on the afternoon of the 14th and following night; in the vicinity of Lake Winnebago and Green Bay the damage was increased by the formation of glaze on wires; windows broken, trees and poles blown down; few buildings damaged.
Utah, entire western half of State.	15					Dust and wind	Comparatively strong, gusty, southerly winds from 9 a. m. until dusk produced an unusually dense and widespread dust storm; visibility reduced to under 55 yards during afternoon; sun obscured much of the day; automobile engines stalled; physical distress reported among persons and animals; minor crop and property damage from high winds which blew down trees and overturned, unroofed or otherwise damaged less stable buildings.
Sumner County, Kans.	17	5:30 p. m.	[1] 2		10,000	Heavy hail	Chief damage to windows, roofs, and automobile tops; path 4 miles long.
Ponca City, Okla.	17	6 p. m.	2,640		500,000	Hail	Crop loss slight because path of storm did not enter the farming district; severe property damage; path 7 miles long.
Braman, Okla., and vicinity.	17	7:15 p. m.	[1] 18		750,000	do	Average crop loss 30 percent; path 40 miles long.

[1] Miles instead of yards.

SEVERE LOCAL STORMS, APRIL 1935—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Reno and Harvey Counties, Kans.	17	8:30 p. m.				Heavy hail	Storm especially severe at Burrton where window panes were broken and automobile tops riddled; small damage to crops.
Frederick, Okla	18	5:30 p. m.	[1] 5		70,000	Hail	Estimated loss to crops, $30,000; property damage, $50,000; path 8 miles long.
Paris, Tex.	18	9:30 p. m.	[1] 10		25,000	Wind	Damage to buildings.
Jasper County, Tex.	19	7 a. m.	[1] 2	1	50,000	Tornado	Property damaged; path 12 miles long.
Grannis, Ark., 2½ miles northeast.	19	8 p. m.	300	0	5,000	do	This tornado hit no houses; occurred in timbered section.
Danville, Ark.	19					Hail	Considerable damage reported; no details.
Cheyenne and Chugwater, Wyo.	23–26					Heavy snow and wind.	Storm covered large area with Cheyenne as the center; snow more than 20 inches deep accompanied by strong wind formed huge drifts, some of which were nearly 25 feet high; Cheyenne and Chugwater most seriously affected, traffic in both places being completely paralyzed; highways leading out of Cheyenne blocked for 2 days; rail traffic seriously interrupted, trains being stuck in drifts southeast of Cheyenne for 2 days; considerable loss to stock; many herds perished before feed could be provided.
McCook, Nebr.	24	3:30–3:45 p. m.	[1] 30		3,000	Heavy hail	No details reported.
Elyria, Nebr.	24	9–11 p. m.	4		5,000	Heavy hail and rain.	Do.
Sabetha, Kans., vicinity of	25			0		Tornadic winds	Corn crib and silo destroyed; barn and outbuildings unroofed; damage over area of 3 farms.
Bains, near, La.	25					Hail	Damage to vegetable gardens.
Rock and Dane Counties, Wis.	26	6 p. m.			10,000	Thundersquall	Several tobacco sheds, a silo and barn destroyed; damage greatest near Albion, in Dane County.
Kingsbury County, S. Dak.	26	12:30 p. m.	440	0		Tornado	Well-defined cloud moving from east to west filled air with thistles and other debris north-northwest of Lake Preston; several small outbuildings on farm destroyed.
Viroqua, Wis., 3 miles west	26	P. m.	1,320	0		do	Barns, sheds, and outbuildings demolished; house partially unroofed; on the north side of the path trees lay from the north, on the south side from the southeast.
Westdale, near, La.	28	7 p. m.		0		Tornado and hail	Damage to buildings; hail caused much crop loss.
Crichton, near, La.	28		[1] 1–2		15,000	Heavy hail	Damage to replanted young cotton and corn; path 10 miles long.
Yorktown, Tex.	29	7:15 a. m.	[1] 2		40,000	Wind	$10,000 property damage; crop loss $30,000.
Nursery, Tex.	29	8 a. m.	[1] 2½			Hail	$1,000 loss to crops; buildings damaged but amount not estimated.
Bethune, S. C., 4 miles south.	29	7:30 p. m.	30	0	150	Tornado	Farm buildings damaged.
Pike County, Ala., northeastern portion.	29			0	4,100	do	3 persons injured; property damaged.
Elizabeth, La.	29		[1] 1	1	52,700	Thundersquall and hail.	Damage to industrial buildings, smokestacks and residences; estimated damage included $2,000 crop loss from hail and $700 in timber; car overturned killing a man and injuring his wife.
Baltimore and Frederick Counties, Md.	29					Wind	Home and 6 shore houses damaged; 6 outbuildings unroofed; 20 trees uprooted and poles blown down in the North Point Road and Bear Creek districts; at Walkersville, Frederick, County, a farmer was struck by a chicken house which had been lifted by the gust.
Woodville-Kirbyville, Tex.	29					Tornado	3 persons injured; houses damaged; loss to crops.

[1] Miles instead of yards.

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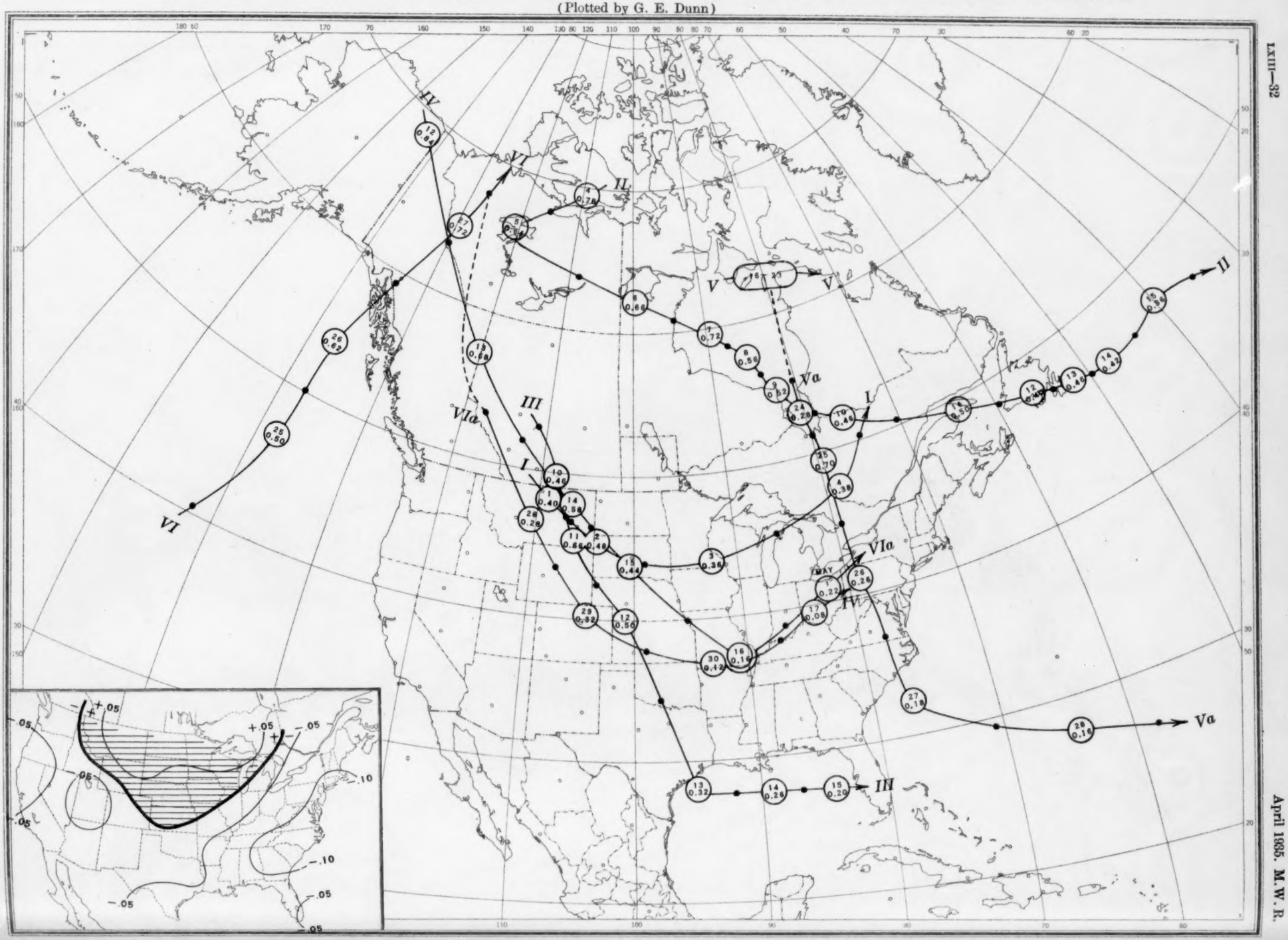
Chart I. Departure (°F.) of the Mean Temperature from the Normal, April 1935

Chart I. Departure (°F.) of the Mean Temperature from the Normal, April 1935

Shaded portions show excess (+)
Unshaded portions show deficiency (−)
Lines show amount of excess or deficiency
Statute Miles
Kilometers

Chart II. Tracks of Centers of Anticyclones, April 1935. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)



Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

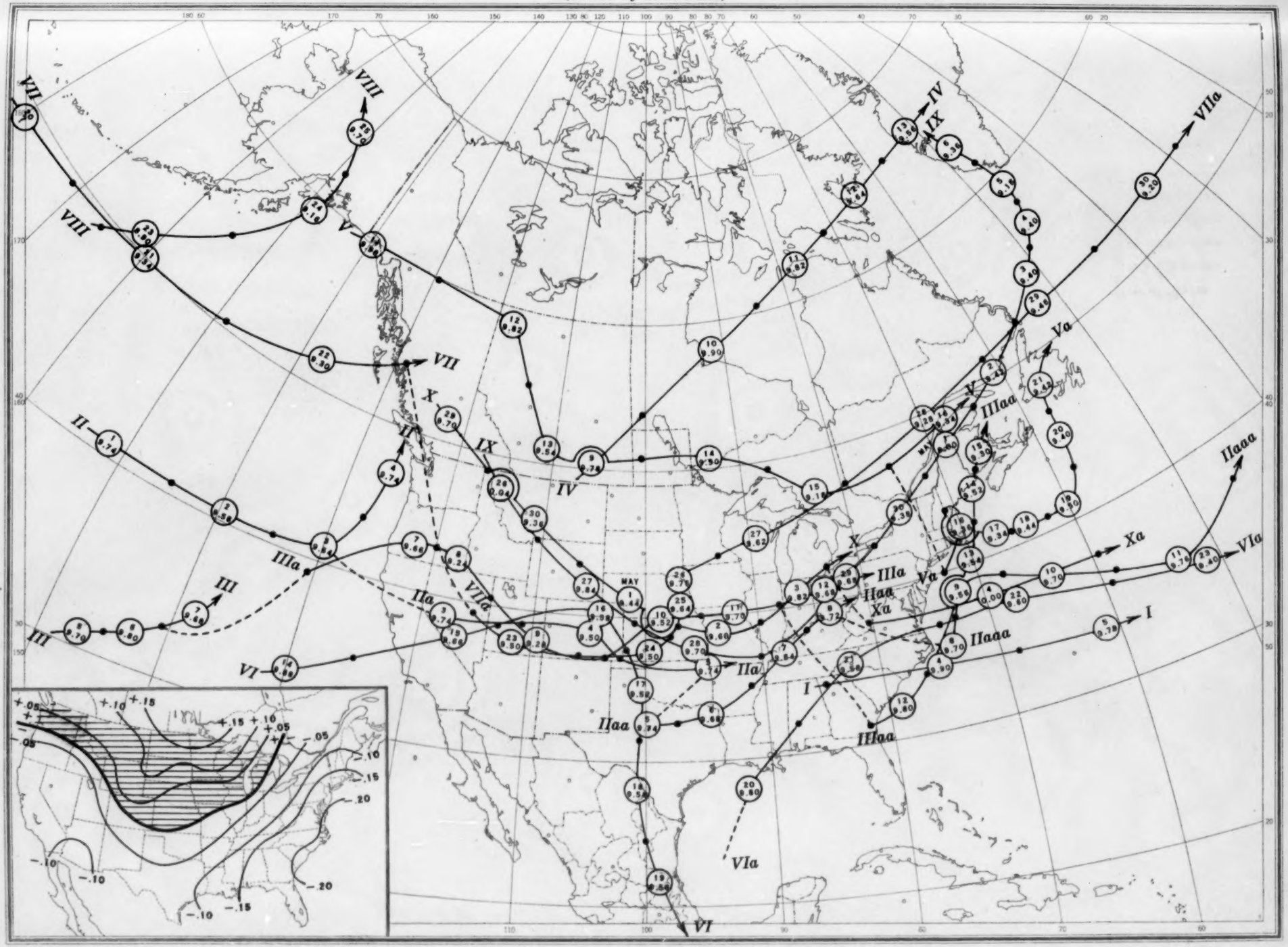
Chart III. Tracks of Centers of Cyclones, April 1935. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, April 1935. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, April 1935

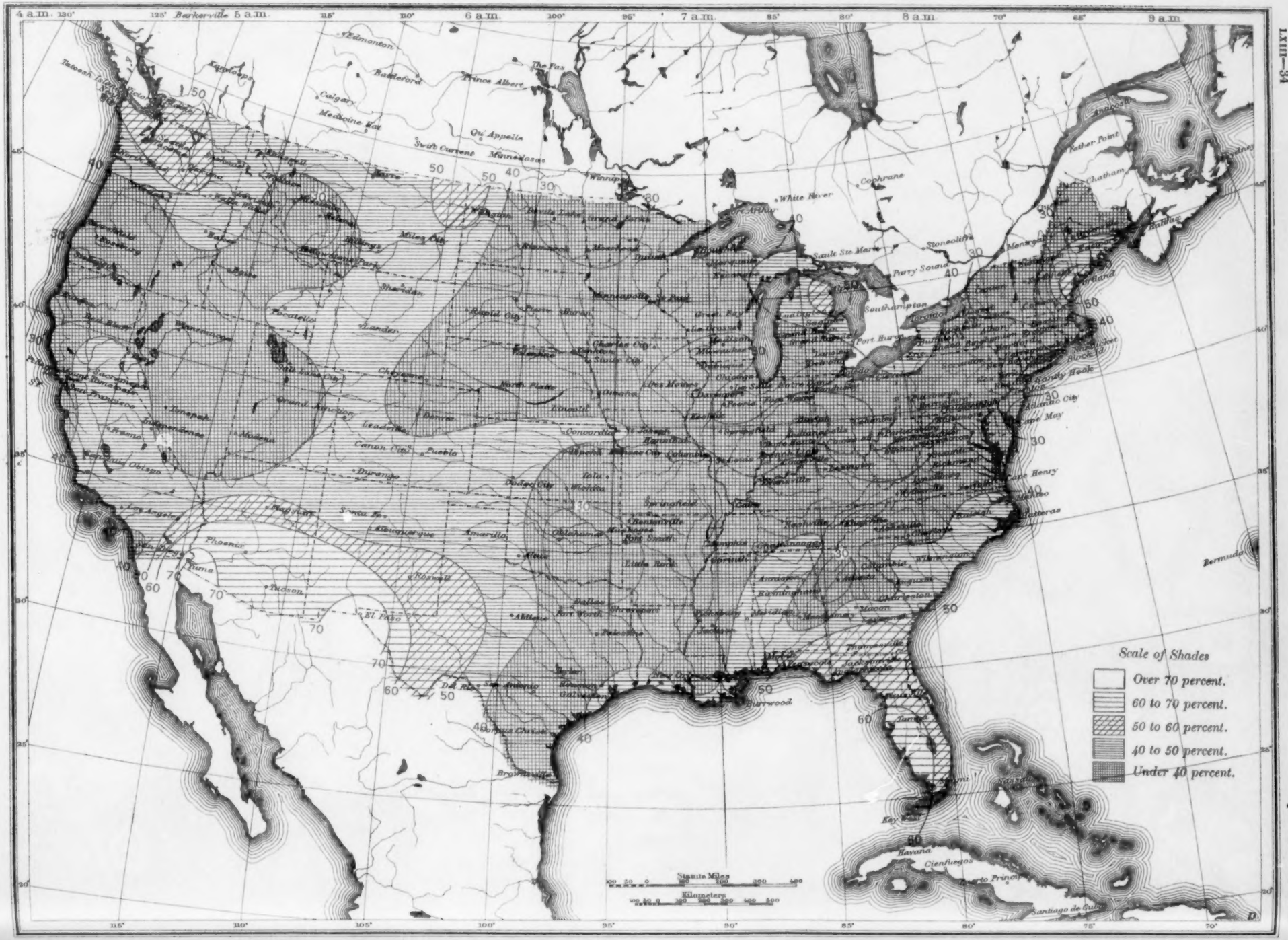


Chart V. Total Precipitation, Inches, April 1935. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, April 1935. (Inset) Departure of Precipitation from Normal

Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, April 1935

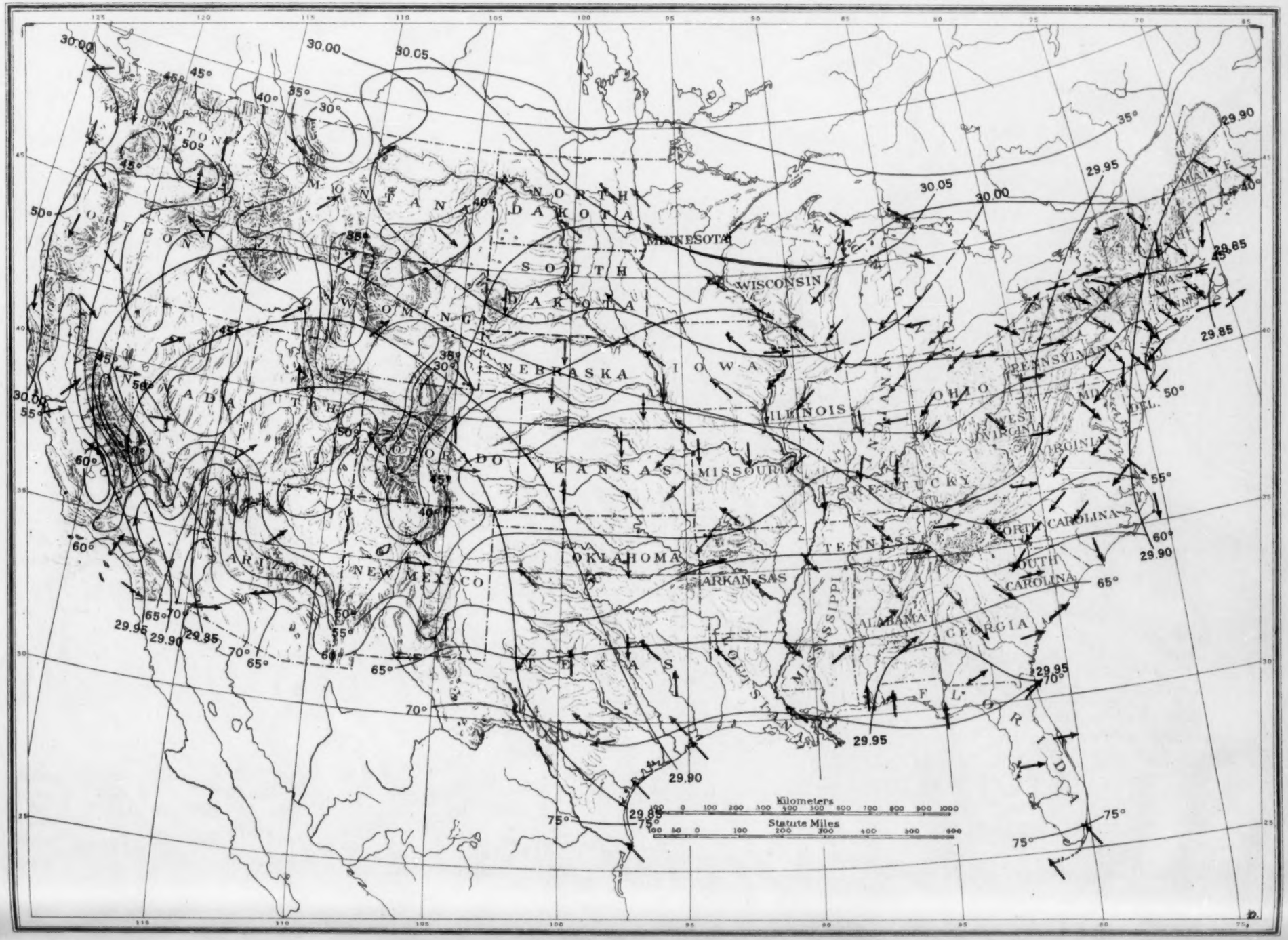


Chart VII. Wind Roses for Selected Stations, April 1935

Chart VII. Wind Roses for Selected Stations, April 1935

(Plotted by E. Corbin)

Chart VIII. Total Snowfall, Inches, April 1935.